G-E THRUST BEARINGS

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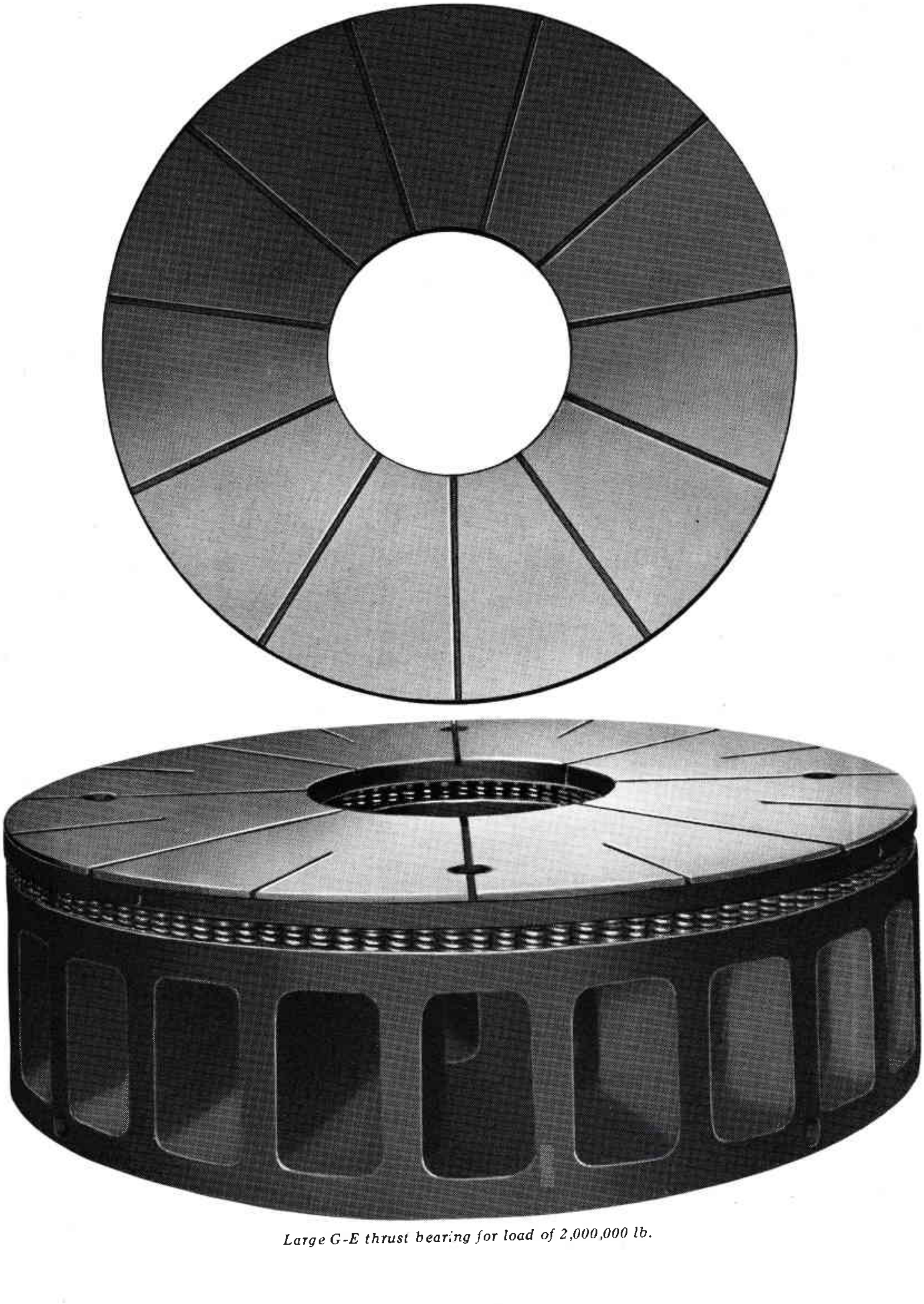
G-E THRUST BEARINGS

GENERAL ELECTRIC
SCHENECTADY, N.Y.

GEA-2251



Large G-E thrust bearing for load of 2,000,000 lb.

FOREWORD

GENERAL ELECTRIC thrust bearings are the simplest and most reliable on the market today. They are readily applicable throughout the entire range in size and speed of vertical machines. They are inherently accessible, require no adjustment during assembly, or scraping to fit the surfaces under load, and are automatically self-aligning to equalize the pressure distribution over the whole surface.

This bulletin, which describes the General Electric thrust bearing, includes an explanation of the function that each part exercises in operation. The more important operating characteristics are discussed and a description of various forms of application for different types of machine constructions is included, together with a list of many of the important hydroelectric units equipped with these bearings.

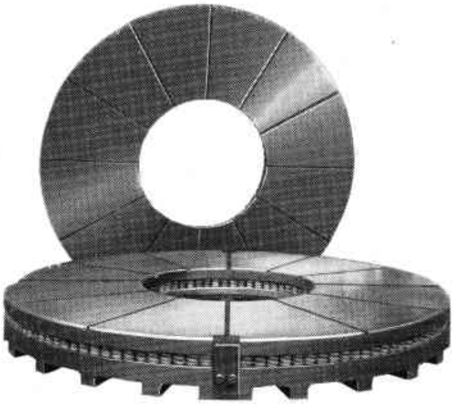
G-E THRUST BEARINGS

THE General Electric thrust bearing consists of a grooved, rotating, steel plate, rigidly fastened to the shaft by means of a thrust block, and a grooved, stationary, babbitted plate. The latter has some flexibility and is supported by a large number of precompressed springs. During operation, a film of oil is maintained between the rotating and stationary plates. This film is thick enough to prevent metallic contact of the surfaces, and results in operation with a low coefficient of friction. It is not sensitive to changes of speed or loading, nor is it so delicate that a small amount of sludge or small particles will disrupt it. When rotation is started, the film forms by the time half of the distance between the grooves is traversed, because both the stationary and the rotating grooves are chamfered to direct the oil between the surfaces. The stationary plate and its spring support are so proportioned that, as the oil film begins to form, the flexibility of the structure insures its assuming a position which will produce the most effective shape of film.

The heat generated in the bearing is carried away by the oil. The grooves in the stationary plate provide one source of cool oil for lubrication, and the grooves in the runner provide another. In addition, the runner grooves, acting as centrifugal pumps, create a profuse flow of oil to remove the heat from the bearing surface. The operation of the General Electric thrust bearing depends upon the combined effects of the grooved rotating and stationary plates and of the flexible support. The paragraphs following describe their functions and present a clear picture of their performance.

RUNNER GROOVES

A thrust bearing, consisting of a solidly supported, plain, stationary plate and a rotating



Typical large thrust bearing, showing grooves in runner and stationary plate

plate, having radial oil gooves with ample chamfers at the leading edge of the sectors, will support a load. This fact was demonstrated analytically about thirty years ago, and many such bearings are in operation today. In such bearings, the oil grooves provide an entrance for cool oil to separate the two rubbing surfaces. A pressure is built up by the chamfer to form a film capable of supporting limited amounts of load, with perhaps high frictional loss. The shorter the length of the segments, the more effective is the establishing and maintenance of the film. Also, within limits, the greater the entering chamfer, the better the running performance, although too extreme values may be detrimental, both at starting and while running. Besides forming an entrance for fresh oil to the following film, the grooves act as scavengers to take away part of the hot oil from the preceding film. As a result of centrifugal force, the oil in the center of the radial grooves has a relatively high radial velocity. This tends to scrub the hot oil off the stationary plate and force it out into the oil reservoir. Just in front of the chamfer, the oil piles up as a result of the tangential velocity head and, although it also has a radial velocity, the resultant action is to provide a constant source of fresh oil for the film. The scavenging effect of the oil grooves has been observed on glass models to be between 15 and 25 per cent of the oil in the film.

STATIONARY GROOVES

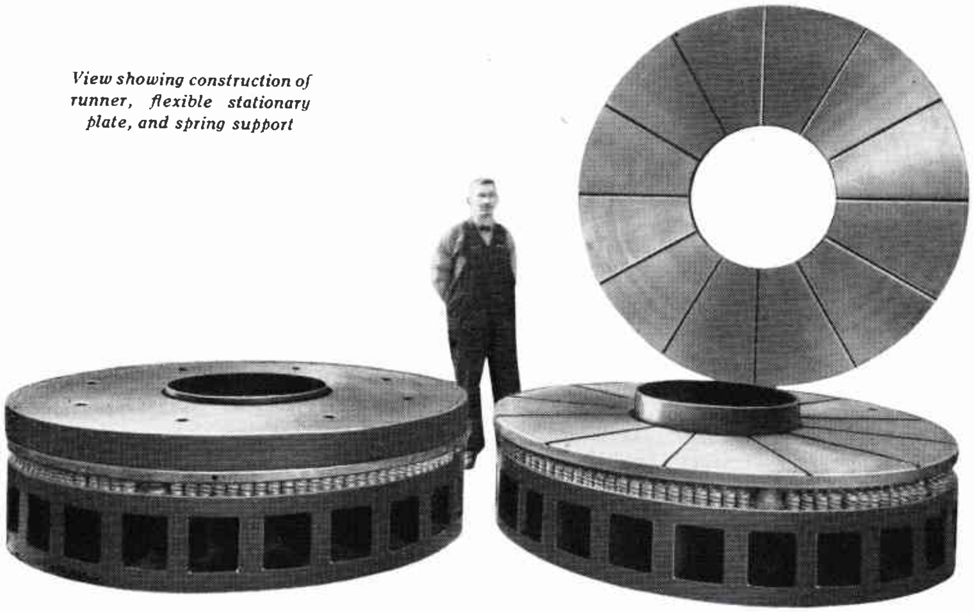
With the exception of the pumping by centrifugal force, a bearing consisting of a grooved stationary plate and a plain runner acts in the same way as one with a grooved runner and a plain stationary plate. There is simply less oil flow, with less renewal of oil; consequently, such a bearing is suitable only for lower operating limits or factors of safety.

There is, however, a very important protective function of the stationary grooves. If the oil is dirty or sludgy, or the bearing starts to wipe, the runner will carry the foreign bodies until a stationary groove is reached. They will then be deposited, unless they are too large, and the bearing will be protected, to quite an extent, from failure. It is evident that the closer these grooves are placed, without impairing other operating characteristics, the greater the protection this will afford.

The stationary plate has a radial saw cut through it to avoid any possibility of dishing of the plate by temperature effects which would distort the otherwise uniform loading of the bearing. In some cases, the stationary plate and the rotating plate are cut into two or more sectors to facilitate handling.

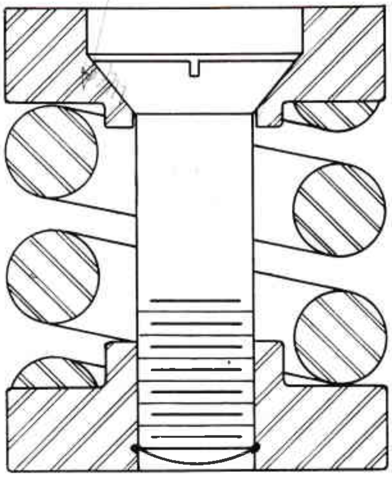
FLEXIBLE SUPPORT

The function of the flexible plate and spring support is to permit the formation of an alternately converging and diverging oil film. By this means, the performance becomes far superior to that obtained with a solid support and may be superior to that of pivoted segment bearings. In bearings of the two last-named types, the oil film must be



View showing construction of runner, flexible stationary plate, and spring support simply converging, since the segments must have sufficient rigidity for the effective point support. In the General Electric bearing, the plate can and does assume the most efficient form which the oil-film conditions, side leakage effects, and changes in viscosity through the film tend to produce.

When G-E thrust bearings were first developed, the springs were free, with only the compression resulting from the effective loading. As an improvement in their design to counteract the secondary effects associated with some hydraulic conditions of waterwheels, each individual spring is now precompressed according to its proportion of the total load for which the bearing is designed. Theoretically, a precompressed spring will not deflect until the loading attains that of the precompression. However, measurements show that, where the precompression is obtained by means of a screw in a tapped washer, as illustrated at the right, the desirable characteristic of small amplitudes of motion with small variations in loading is obtained. This gives the assembly sufficient flexibility so that the principal force which resists deformation of the plate, even under adverse conditions of nonuniform or light loading, is the stiffness of the plate itself, resulting in a regular deformation as determined by the film requirements. If, for any reason, the line-up of the unit becomes imperfect, the flexible support will automatically and continually deflect to equalize effectively the pressure distribution over the entire bearing.



Individual spring, showing method of precompression

OPERATING CHARACTERISTICS

LOSSES

In electric machines, bearing losses are relatively unimportant, as far as machine efficiencies are concerned, because of their small magnitude in comparison with other losses. Consequently, the main purpose of having accurate data on losses is associated primarily with methods of cooling or otherwise dissipating bearing losses without excessive temperature rises.

The technical press is replete with articles discussing careful measurements and methods of observation to determine the losses accurately. These articles are significant in their lack of uniformity in results, simply because so many widely variable factors, such as temperature, viscosity, temperature effects of oil, finishes, and loading conditions, all enter into the determination, to say nothing of the difficulties of segregating thrust bearing from guide bearing, or other even more important, losses.

Field tests on completed units give fair accuracy when cooling coils are utilized for removing bearing losses, and the flow and temperature rise of water can be very accurately determined, although losses of heat by direct radiation and conduction are quite uncertain quantities. Where a guide bearing has the oil bath common with the thrust bearing, no satisfactory method of segregation is available. Numerous laboratory tests have been made to determine, as accurately as possible, losses on various types of thrust bearings. Only minor differences are discernible, and they are of less significance than variations accompanying ranges in loading temperatures, and viscosity during operation.

General Electric thrust bearings are designed for loadings of approximately 400 lb per sq in. With this loading, the film thickness is as large, and the coefficient of friction as small, as can be obtained with a factor of safety which will provide for usual operating contingencies.

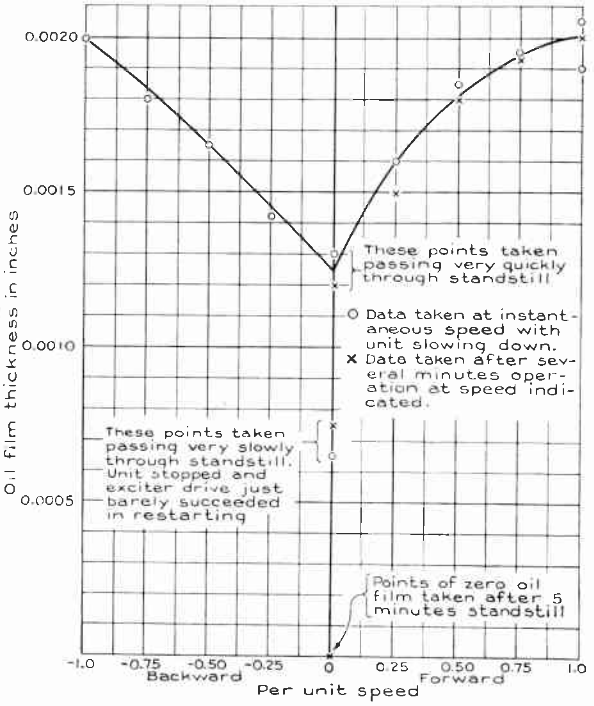
WEAR AND NOISE AT STARTING

Such progress has been made in thrust-bearing design and manufacture that a thrust bearing is one of the parts of a machine which requires the least attention during normal operation. There is practically no wear, with the possible exception of that which may occur at the instant of starting and before the oil film is formed. The wear under these conditions is small, for one reason, because of the inherent characteristic oil has of depositing a greasy residue on the surfaces, which residue has sufficient stability to persist until a complete film is formed. This is evidenced by the low coefficient of static friction of 0.08 to 0.10 occasionally observed. Another reason for small wear lies in the use of a babbitt with minimum dry-wear rate and minimum tendency to crumble or fail under pounding. Incidentally, this babbitt also has a very low chemical action on oil, a property desirable since excessive saponification produces early failure of a lubricant.

Many operating companies have noticed, in their vertical units, after a shut-down period of any extent, that there is a distinctly audible noise at the instant of starting. This noise has been variously described as a grunt, twang, or groan. It does not appear to be peculiar to thrust bearings of any particular manufacture. Because of the apparent erratic characteristic of the noise, it has sometimes been erroneously attributed to frictional distress. Observations on a number of machines show that, even if the noise energy produced were only one per cent of the total energy involved, this energy would be very small in comparison with any energy required at bearing failure. By using a sound-level meter, it has been found that the major part of the sound generally emanates from some part of the structure which resonates freely, as, for example, a cover over the top of the oil housing. The starting of relative motion between surfaces initially at rest is an alternate change from static to greasy friction and then back to static, similar to the passage of a finger, at the proper angle, over a dull surface. When sufficient velocity is attained between the points of metallic contact, the static friction is eliminated. Hence, it may be seen that the starting of a waterwheel-driven unit consists of a series of forward jumps and stops until an oil film is formed or for a minimum distance corresponding to one-half the distance between bearing grooves. During the period of this jerky motion, resonating parts are set into vibration, producing the noise.

OIL-FILM THICKNESS AND STABILITY

The oil film in a thrust bearing is of an alternately diverging and converging shape, the minimum value being of the order of thousandths of an inch, depending upon such factors as load, speed, and oil viscosity. The curve below shows the variation of minimum film thickness with regard to speed for a particular machine. It is not strictly a function of speed, but also involves time in a rather complicated manner, so that, at zero speed, the oil film requires time to become established, or when it is once established, time is required for it to vanish. It, therefore, has an essentially stable characteristic—not readily destructible by effects of short duration. Because of the "residual" oil film at zero speed, once even a very large machine is started rotating, it can be maintained in motion by hand by one or two men.



Curve showing variation of oil-film thickness with change of speed

Two men can often restart a large machine and keep it rotating by hand after it has been stopped for an instant.

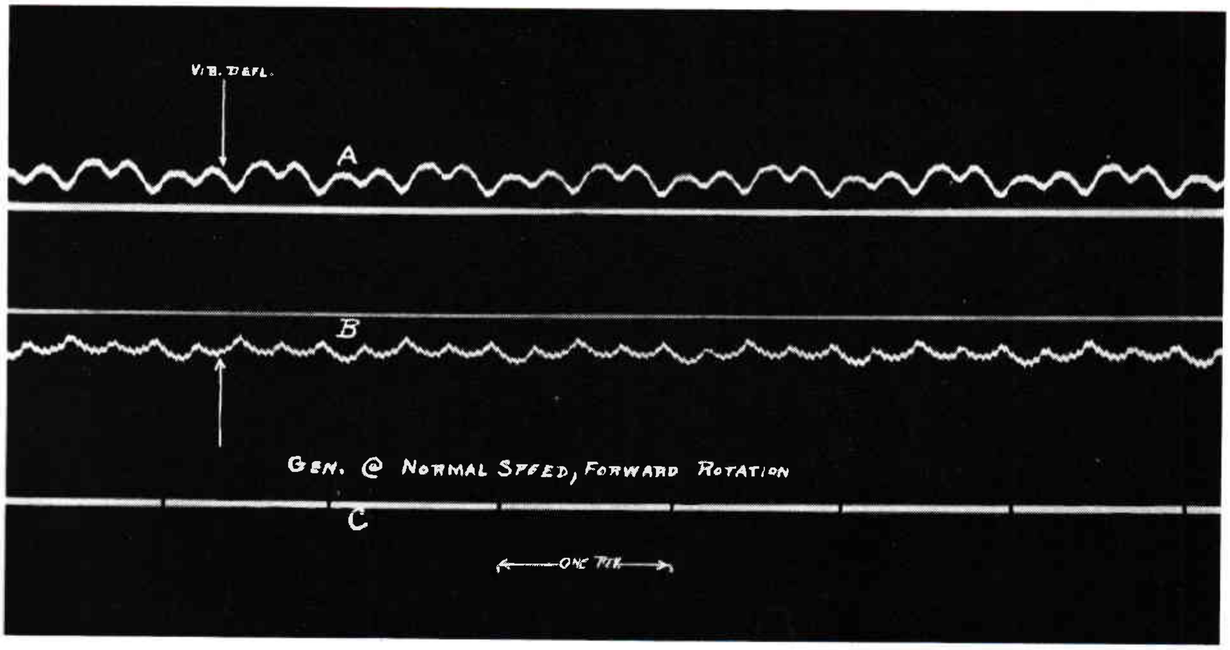
An excellent illustration of oil-film stability at low speeds was afforded by a series of accidents which required a General Electric bearing, of 92-in. outside diameter with a normal speed of 88 rpm, to carry the weight of the rotating parts (about 1,400,000 lb) for more than two hours at 2 or 3 rpm. Subsequent to this inadvertent operation, the bearing surfaces were examined carefully and no distress whatsoever was discernible.

MOTION OF FLEXIBLY SUPPORTED PLATE DURING OPERATION

The action of the stationary plate under all conditions of starting and operation has been mathematically analyzed, and thorough studies by means of an oscillograph have completely confirmed the results. The oil film is thickest at the entering edge, causing a slight depression of the plate, which takes the form of waves or ripples, each following a rotating oil groove. These waves are continuous, even over the plate at the radial saw cut, although of somewhat different magnitude. The oscillogram below shows the motion of the flexible plate during operation at normal speed. (Note: The small high-frequency ripples shown are unfiltered harmonics of the testing circuit, and are present in the record with the machine standing still.) The springs for this test were precompressed to the equivalent of 4.5 times the test load. The motion is essentially the same with free or slightly precompressed springs.

Of the many thrust bearings on the market, the General Electric bearing is the only one which automatically relieves the high local pressure which might occur as a result of inaccuracies of workmanship. Also, it adjusts itself for misalignment conditions which might occur in installations. The thrust block in the bearing for which tests are shown was 0.0015 in. higher on one side than on the other. This introduced an irregularity in the deflection characteristics during rotation, the plate assuming a position inclined slightly to the horizontal as seen on the oscillogram, In spite of the eccentricity, the waves are essentially equal in area from one position to the other, showing complete, automatic equalization of local pressures.

Oscillograms taken during starting show that the oil film is built up by the time a rotor groove has moved the distance of half a segment.



Oscillogram showing deflection of stationary plate A—Opposite radial saw cut B—At radial saw cut

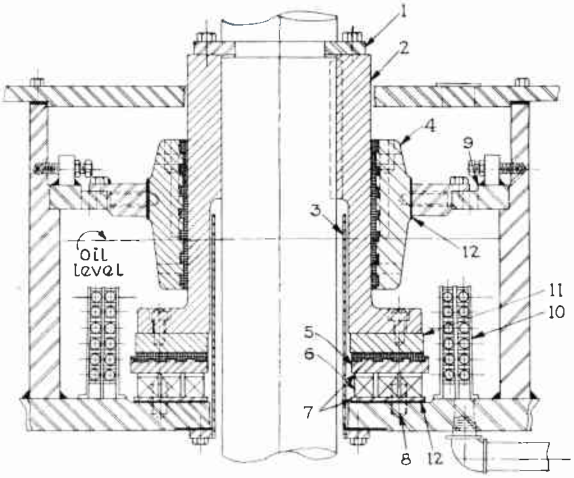
TYPES OF CONSTRUCTION

BEARING ARRANGEMENT

1. With the conventional bearing arrangement, in use for many years on vertical machines, the thrust bearing is located at the top of the machine with upper and lower guide, or steady, bearings. This provides maximum bearing accessibility since the continuous bearing plates can be lifted out after removing exciters or other equipment mounted above the bearing.

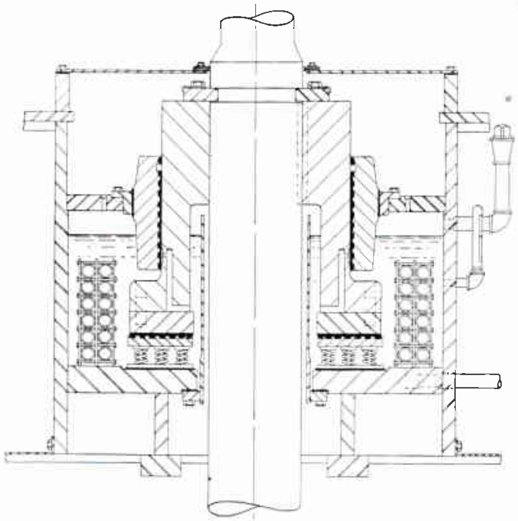
In the smaller sizes the upper guide bearing is of the "combined" type acting on the collar of the thrust bearing. This results in a self-oiling guide bearing which pumps its own oil. The illustrations on this page show this type of construction. In the illustration below, the oil supply to the guide bearings is through suitable grooves in the babbitt. The two illustrations at the right show an arrangement wherein the intake is through passages in the thrust collar. These lead to spiral grooves in the journal surface. This construction gives very positive action at low shaft speeds. With either arrangement, the lower guide bearing is separately oiled, usually by means of a geared pump.

In larger sizes, where radial-arm upper brackets are required in order to support the very heavy loads encountered, it is preferable to employ a separate upper guide bearing, located at the center of the radial arms, while the thrust bearing is located in a shallow housing above the bracket. The illustration on page 9 shows a sectional view of such a machine. The generator has a unit oiling system. Oil is supplied to both guide bearings by a pump geared to the generator shaft.



1. Split Retaining Ring
2. Thrust Collar
3. Oil-well Tube
4. Guide Bearing
5. Stationary Babbitted Ring
6. Springs
7. Clamps for Springs
8. Dowel Pin
9. Guide Bearing Support
10. Cooling Coils
11. Rotating Ring
12. Insulation

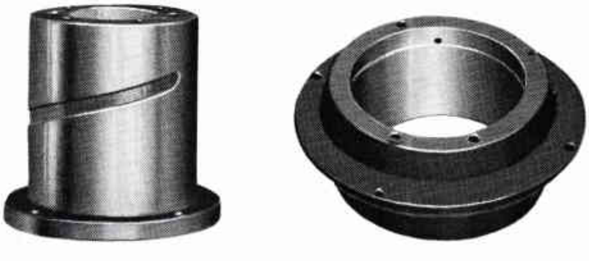
Sectional view of combined upper guide and thrust bearing



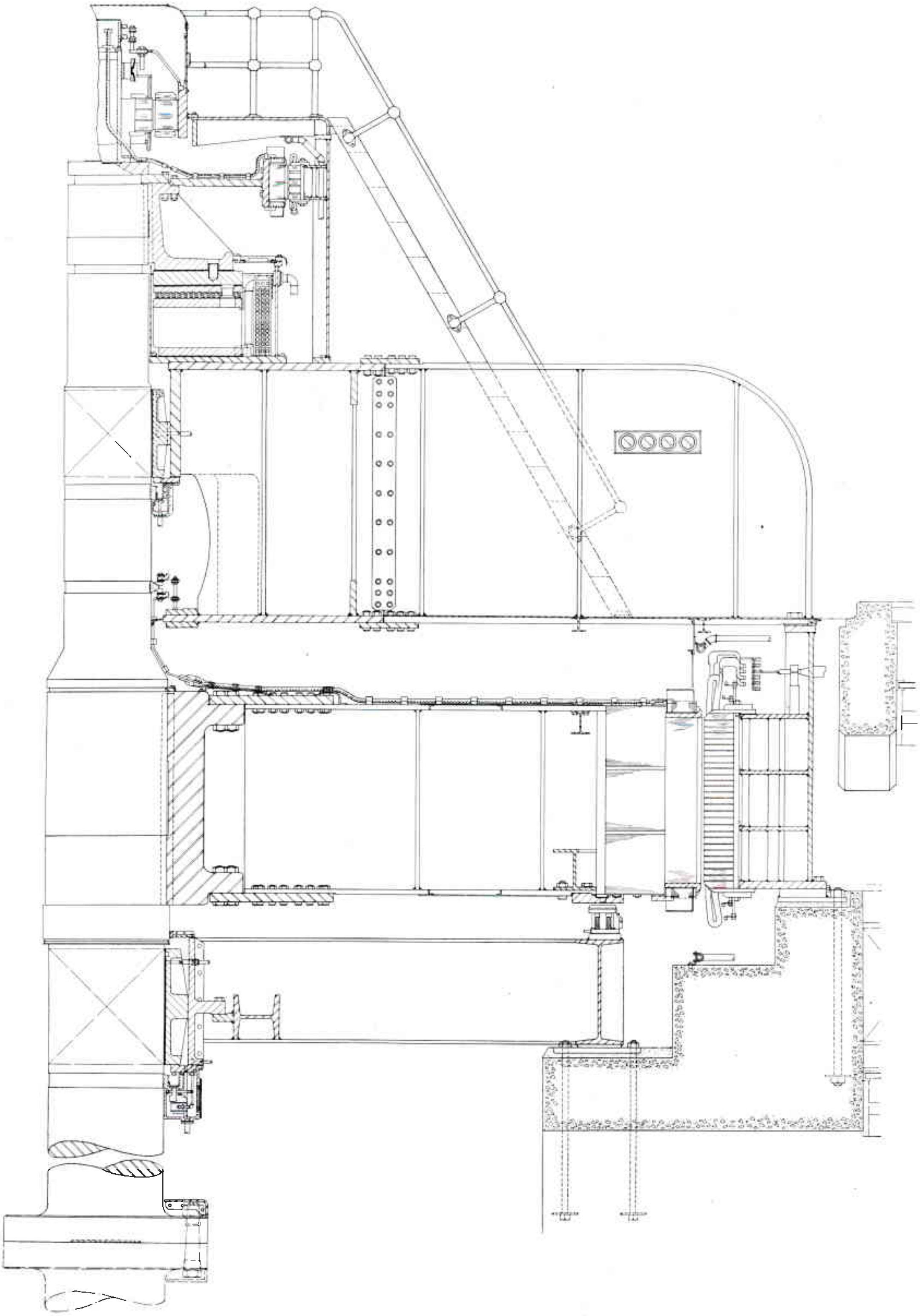
View of combined guide and thrust bearing with guide bearing lubricated through passages in thrust collar

The guide bearings are furnished in two or more sections when necessary for assembly. The combined bearings may be removed by raising them out of their seats, removing the joint bolts, and withdrawing the segments horizontally. After removal of the oil pans, the separate guides can be lowered, split, and carried out horizontally without disturbing other parts of the unit.

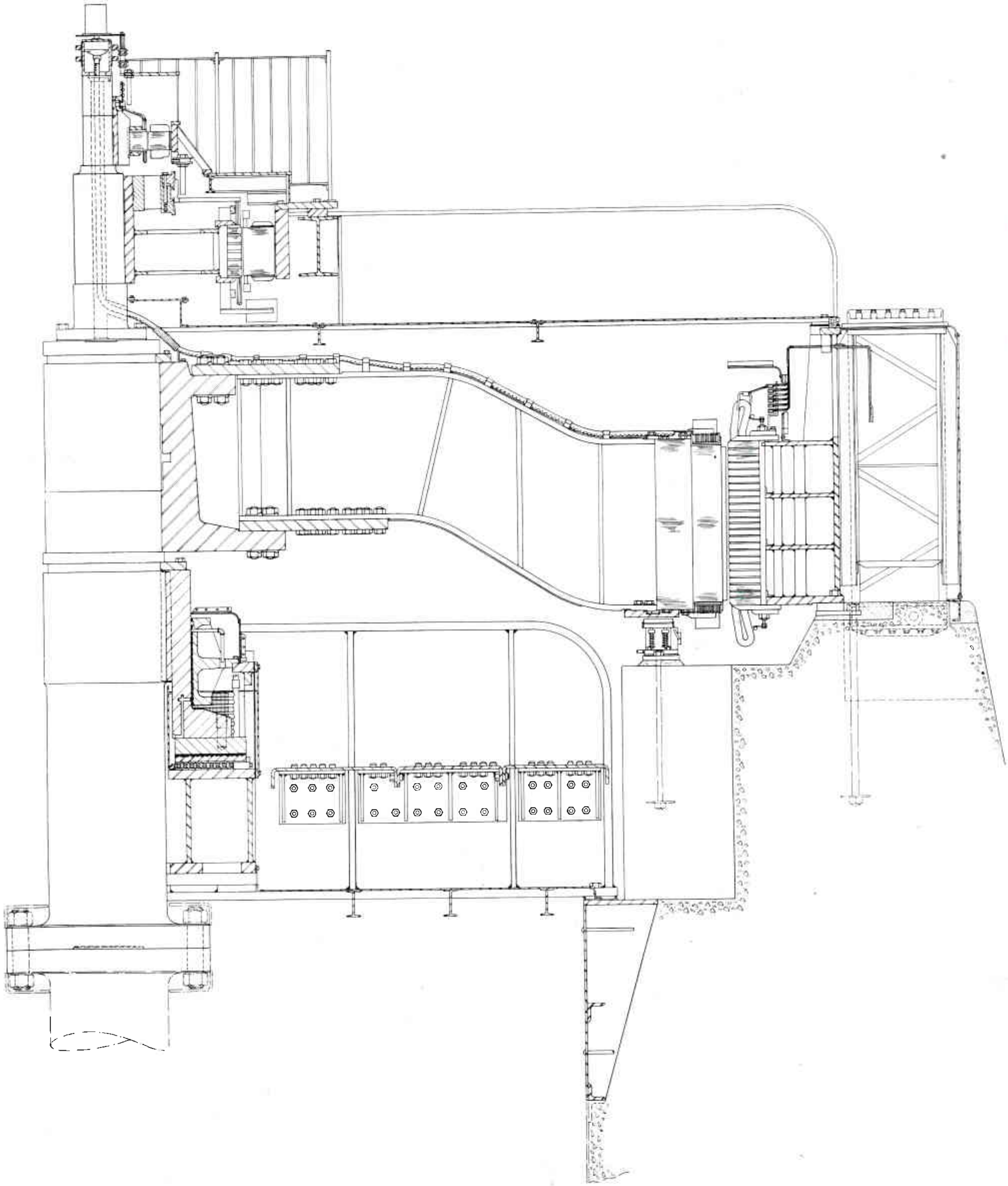
2. In recent years, a number of machines of the overhung type have been built, chiefly to per-



Thrust collar and guide bearing, showing oil grooves



Sectional view of large waterwheel generator with separate upper guide and thrust bearings and lower guide bearing



Sectional view of large overhung waterwheel generator with a combined guide and thrust bearing mit a saving in station headroom. In these machines, the thrust bearing and a guide bearing are placed immediately below the rotor, and the upper guide bearing is omitted. Alignment, therefore, depends upon both generator guide and waterwheel guide bearings.

Some characteristics of this type of construction are as follows:

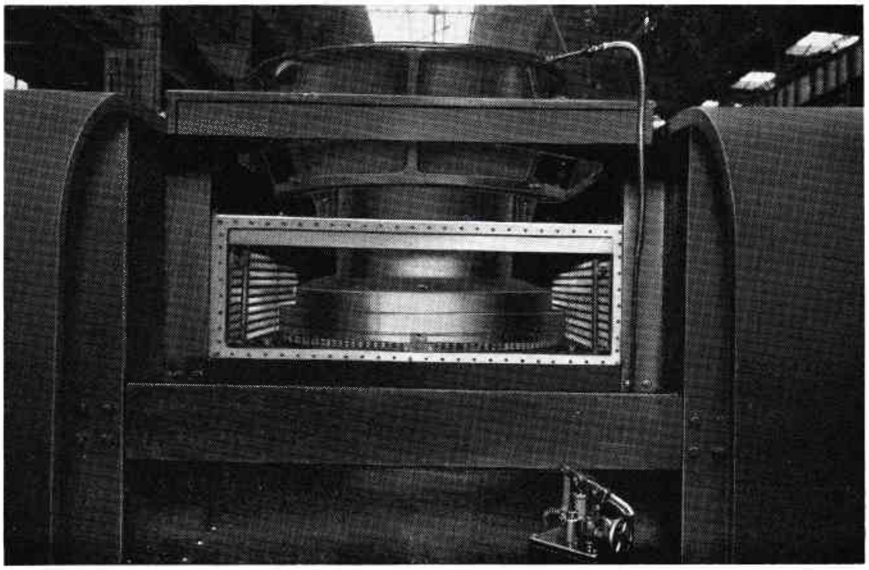
a. It is limited to moderate or low speeds.
b. Station headroom may be lower if generator lift is limiting feature.
c. The generator price is slightly lower.
d. Stator and rotor are more accessible.
e. Location of the thrust bearing below the rotor involves special problems in providing for accessibility of the thrust bearing, particularly in small machines. In the larger sizes, the bearings can usually be made accessible without disturbing the major parts.
f. The oiling system is somewhat simplified.
g. Generators of this type cannot be tested in the field with the waterwheel disconnected.
h. The generator inherently has less mechanical stability during transient electric or hydraulic disturbances.

Where an appreciable saving in station cost can be made by the reduction in headroom, and where the speed is suitable, this construction is justifiable. Other advantages are, in general, of a minor nature.

Either a combined guide and thrust bearing, or separate guide and thrust bearings, can be used, depending on size and other characteristics. The illustrations on this and the page opposite show a 47,000-kva unit employing a combined guide and thrust bearing. The housing is integral with the bracket. The thrust-bearing plates are in halves and can be taken out sidewise through the covered openings. The guide bearing is raised out of its seat by hydraulic jacks, the halves are unbolted, and moved out on carriages running on the top of the main girders.

3. More recently, in order to obtain greater mechanical stability than can be had with the overhung construction, a third type of machine has been devised. This consists of a bearing arrangement similar to the overhung, except that an upper guide bearing is employed. The saving in headroom over the conventional machine with a thrust bearing above and two guide bearings is almost as great as can be realized with the overhung unit; yet it has the inherent mechanical stability of the conventional machine and can be tested independently of the waterwheel.

This type of machine is finding increasing acceptance, particularly in important stations where continuity of operation is paramount.

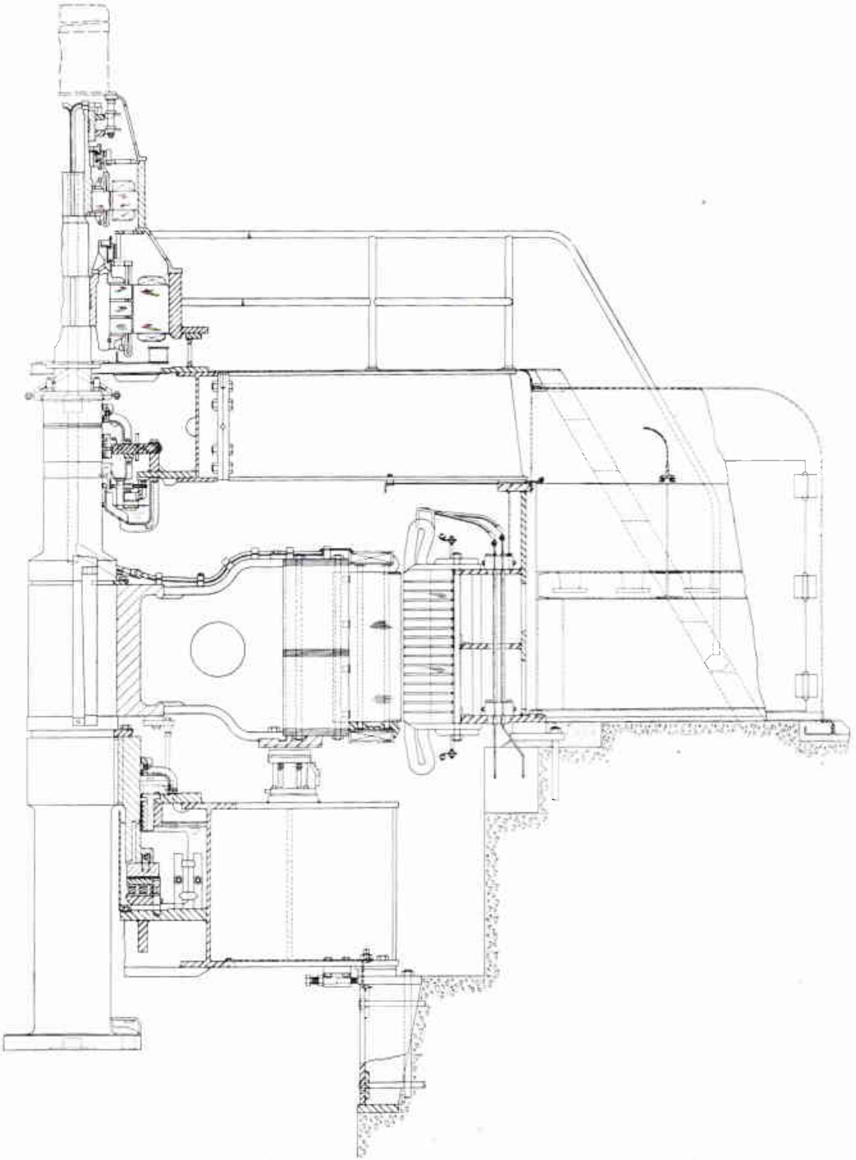


Combined guide and thrust bearing for large overhung waterwheel generator

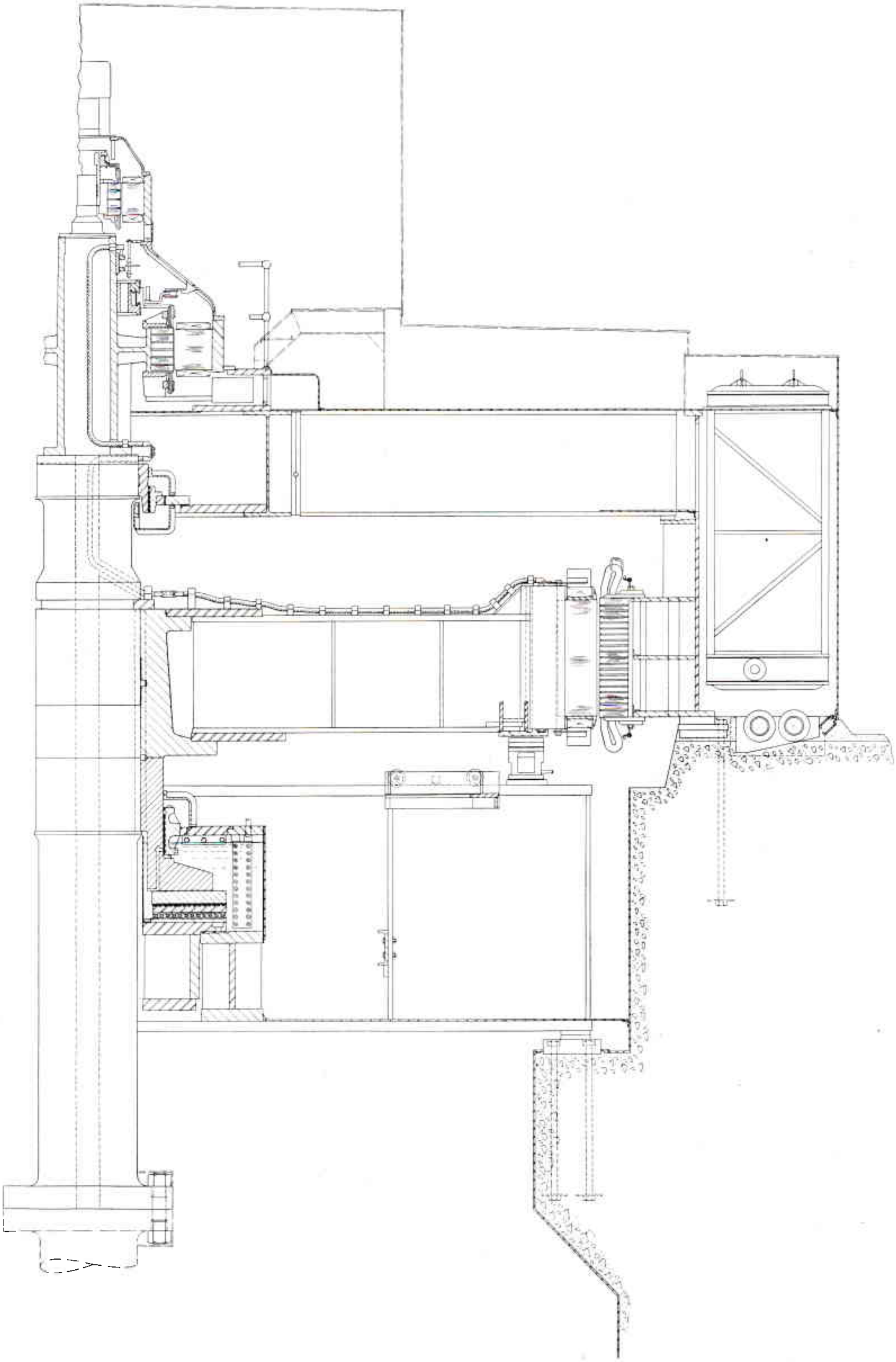
It is realized that this type has no advantages over the conventional arrangement unless the reduced headroom can be converted into a saving in station cost or unless an outdoor or semioutdoor installation is contemplated. In the latter case, there are some advantages in having the thrust bearing located beneath the rotor so that bearing disassembly can be carried out without disturbing the outdoor housing.

This construction is shown below, where the lower guide bearing is combined with the thrust bearing and operates in the same oil bath. The upper guide bearing has its own self-contained oiling system, which employs a geared oil pump.

The illustration on page 13 shows the same bearing arrangement, except that the upper guide bearing is made self-oiled without the use of a pump, by means of a sleeve on the shaft. The use of a separate base or support for the thrust bearing permits the coupling to pass through the bracket, and allows the thrust collar to be assembled permanently on the shaft in the factory.



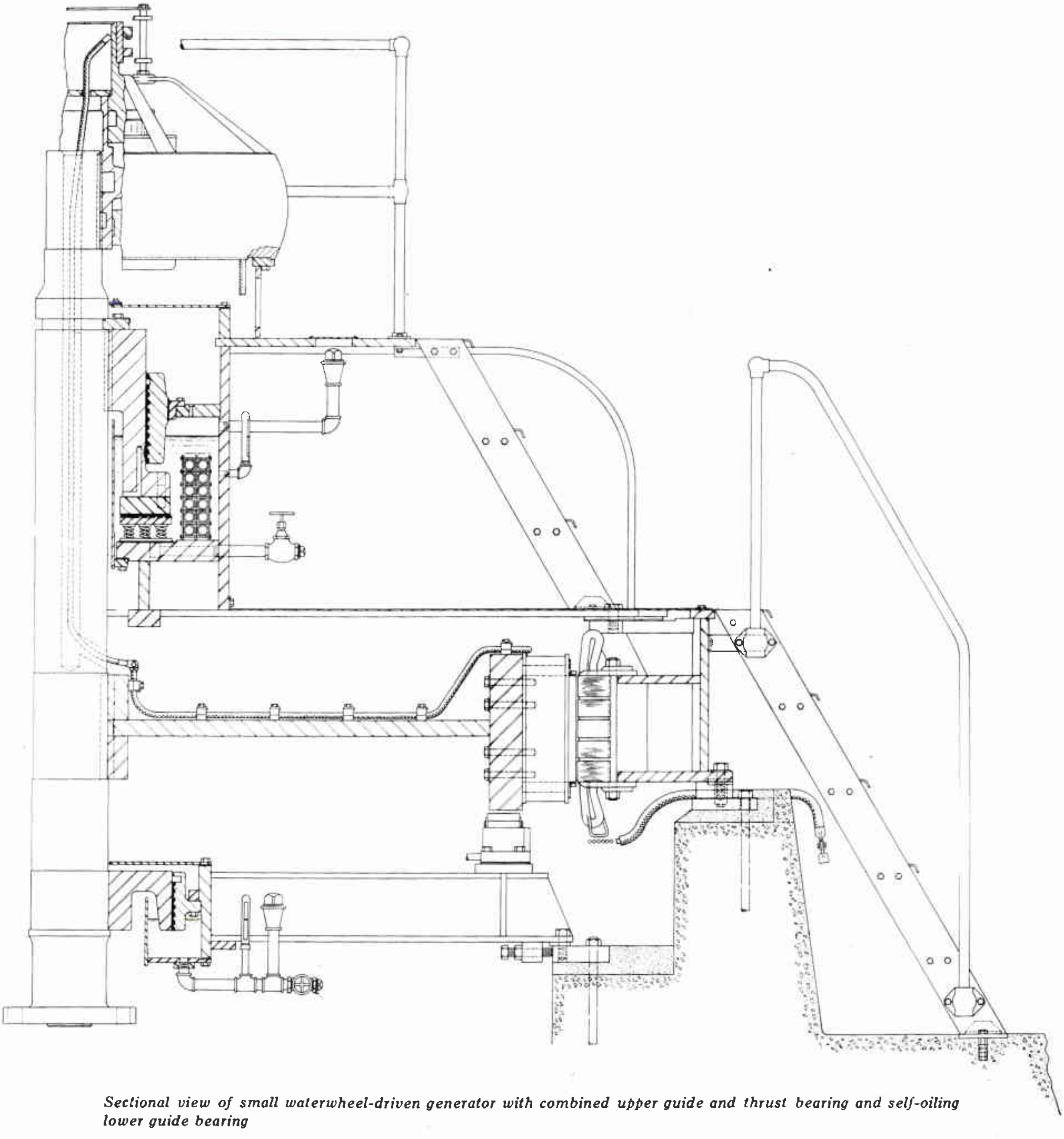
Sectional view of waterwheel generator with combined guide and thrust bearing below the rotor and pump-oiled upper guide bearing



Sectional view of large waterwheel generator with combined guide and thrust bearing below the rotor and self-oiling upper guide bearing

OILING SYSTEMS

Earlier practice employed station oiling systems in which all oil was circulated through a station filter and back to the bearings. In stations where the number of units was large, the piping required was quite complicated, and a unit oiling system was developed as an improvement. This provided a small filter for each machine, and the oil was circulated through the filter and back to the bearings, usually by means of gear-driven pumps. It has been found that continuous filtering of oil is unnecessary, and the oiling system is now further simplified by operating thrust bearings, and guide bearings of the combined type where used, in a self-contained oil bath. In general,



Sectional view of small waterwheel-driven generator with combined upper guide and thrust bearing and self-oiling lower guide bearing separate guide bearings employ a geared pump which pumps oil past a sight-flow indicator and to the top of the bearing.

In some cases, separate guide bearings have been made self-oiling without the use of a geared pump by means of a sleeve on the shaft. This results in an arrangement similar to that of the combined guide bearing which pumps its own oil. The illustration on page 14 shows a machine with a combined upper guide and thrust bearing and a self-oiling lower guide bearing.

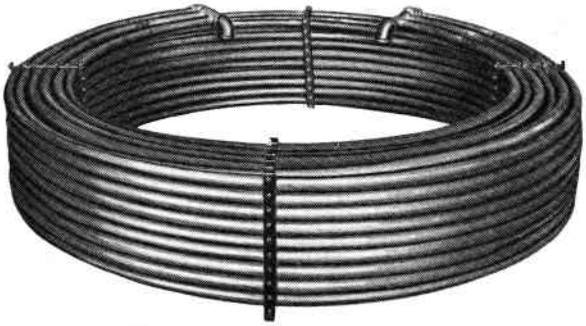
Because of the heavy loads carried on the thrust bearings of vertical generators, it is very essential that only high-grade lubricating oil be used. Oil should be purchased directly from oil manufacturers of recognized standing who will assume the responsibility for the selection of the best oil for the service.

Experience has shown that, in general, the viscosity of the oil at a temperature of 100 F as determined by the Saybolt viscosimeter, should not be less than 200 seconds, or much more than 300 seconds.

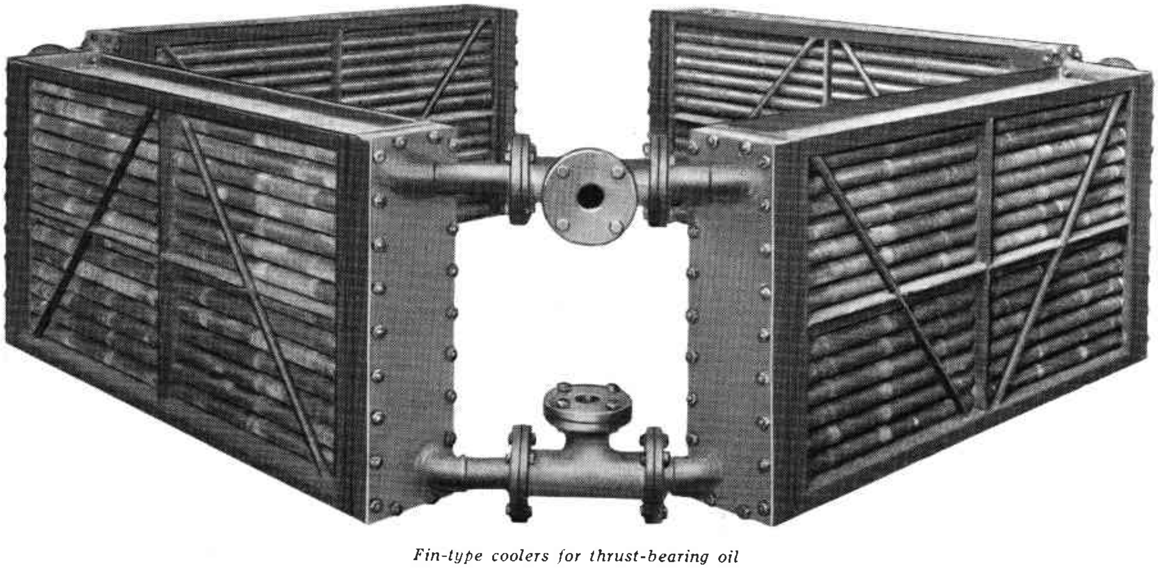
BEARING COOLING

Small thrust bearings may be run air-cooled, but the larger ones require other means for removing heat from the oil and housing. The simplest and most common way to keep the oil cool is by the circulation of water through coolers in the oil bath. The standard coolers are designed to maintain the required oil-bath temperature when supplied with water at a temperature of 25 C and at the rate specified by their manufacturer for each case. Trouble with the bearing surfaces is generally accompanied by a quick rise in oil temperature over that encountered under normal operating conditions.

In some installations, water pressure is not available for the bearing housing without special pumps. In these cases, the oil is cooled by pumping it through an external cooler. The pumps are driven directly from the generator shaft or by separate motors, and the coolers are of either the air or water type, depending upon local conditions. Motor-driven pumps are ordinarily furnished in duplicate, and the two units usually have different power supplies.



Water-cooling coil for thrust-bearing oil



Fin-type coolers for thrust-bearing oil

INSTALLATION OF GENERAL ELECTRIC THRUST BEARINGS

The simplicity of the bearing—which consists of only three principal parts: a stationary plate, a rotating plate, and a set of springs—together with the inherently uniform loading obtained with the spring support, makes the General Electric thrust bearing the simplest and quickest to install or disassemble.

FACTORY FINISH AND PROTECTION DURING SHIPMENT

The bearing surface of the rotating plate is carefully ground and polished at the factory to obtain a true and smooth surface. The stationary babbitted plate is machined to a uniform thickness. Because of the flexibility of this plate and its spring support, the General Electric thrust bearing can be put in service without fitting or scraping.

All steel or iron bearing surfaces are shipped from the factory with a protective coating to prevent rust. The rotating plate is packed in a special manner to prevent the protective coating from rubbing off and the polished bearing surface from being scratched.

ASSEMBLY OF THE BEARING

The protective coating on the bearing surface is easily dissolved by benzol, gasoline, or kerosene and removed with the use of clean rags (*not cotton waste*) and wood scrapers.

Before assembly, all parts of the bearing and the bearing housing should be inspected to insure absolute freedom from dirt, lint, or other foreign matter. Next, the bracket should be lined up and leveled. If a bearing base ring is used, this should then be brought into position and lined up by dowel pins. Next, the springs should be assembled on the base or floor of the housing. The babbitted stationary plate should then be placed on the springs and dowels which line up and hold the plate to prevent turning. Before assembling the rotating plate, the rubbing surfaces of both plates should be inspected to be sure that they are free from scratches. Then, the stationary plate should be covered with grease or preferably with a thick mixture of heavy lubricating oil and fine flake graphite. When the runner plate is lowered, it may easily be rotated to line up with the vertical dowels in the thrust collar.

On the overhung type of generator where the thrust bearing is located below the rotor, the stationary and rotating plates are made in halves to make possible their assembly and disassembly without disturbing the rotor. The bearing parts are assembled in the order described above, but, instead of being lowered over the top of the shaft, the half plates should be carried horizontally into the bearing housing through large openings provided for this purpose. This is the arrangement shown in the illustration on page 11. Where the bearing parts are very heavy, special carriages are provided for assistance in removing or reassembling the bearing.

Where the thrust bearing is located above the rotor, insulating material is used either under the base ring or between the thrust collar and rotating plate, to prevent flow through the bearing of circulating currents from the shaft. After the bearing is assembled and partially loaded, this insulation should be given a high-potential test of 500 volts. When the thrust bearing is below the rotor, it need not have any insulation against these circulating currents.

As soon as the bearing parts and cooling coils are assembled, the housing should be filled with clean lubricating oil. This protects the metallic parts from rust during the period required to finish the assembly of the generator; the bearing is then ready for service whenever the generator is ready to start.

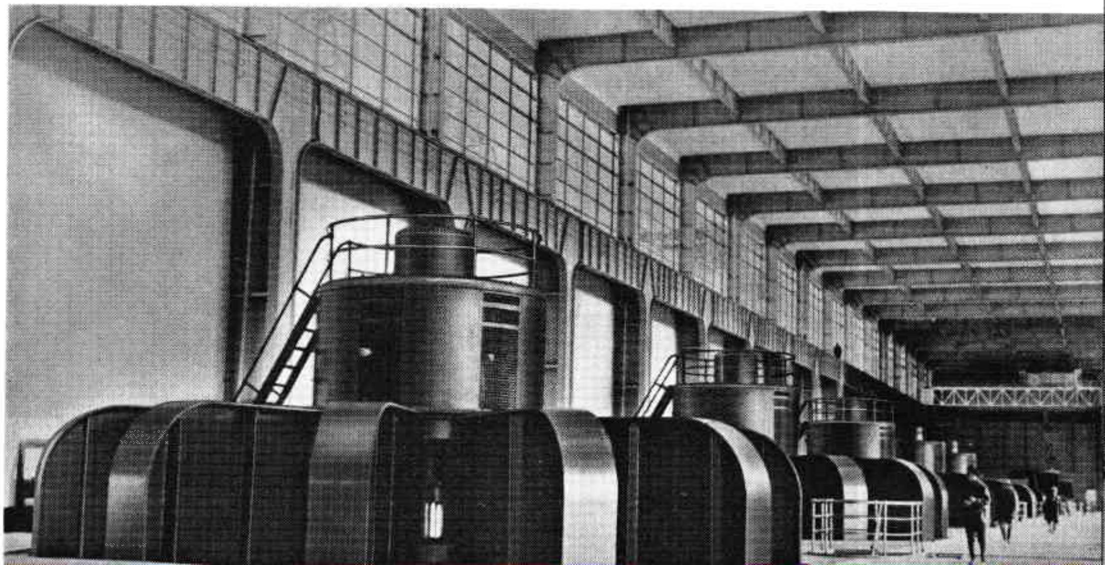
INITIAL STARTING

If there are cooling coils in the thrust-bearing housing, turn on the water before starting. Start the bearing slowly and run at one-third speed for half an hour and, at first, note the oil temperatures at one-minute intervals. Any injury of the rubbing surfaces will be indicated by a rapid rise of the oil temperatures in the housing.

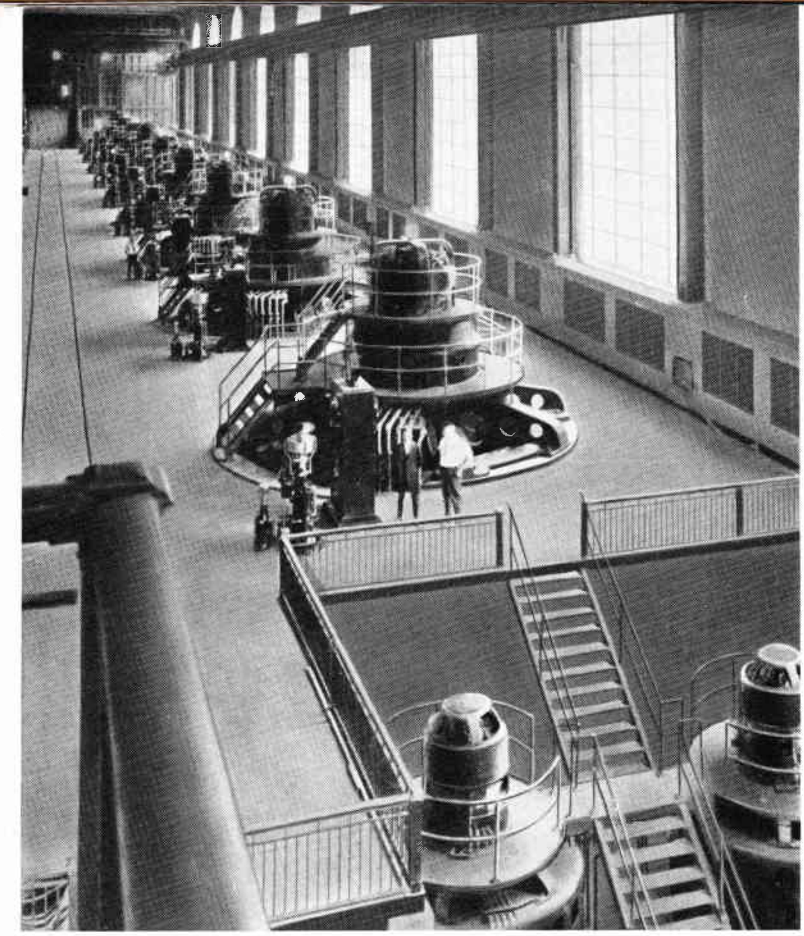
If the bearing operates well at one-third speed, the speed may be gradually increased to normal.

PARTIAL LIST OF INSTALLATIONS OF VERTICAL-SHAFT MACHINES WITH G-E THRUST BEARINGS

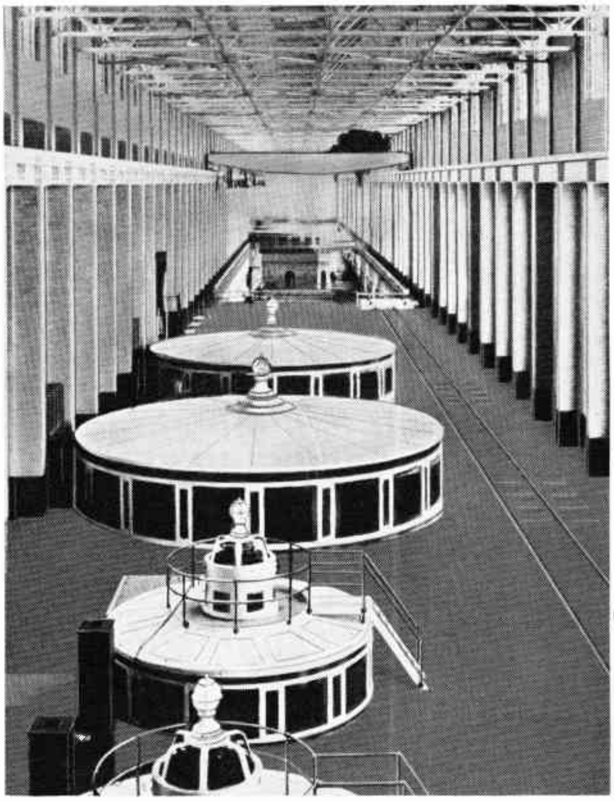
Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
U. S. Dept. of Interior Boulder Dam	82,500	180	1,786,000	2	1936
Dnieper River Development, U.S.S.R.	77,500	88	2,000,000	9	1932-33
Hydro-Electric Power Com. of Ontario, Queenston	54,000	187	950,000	5	1922-25
Ontario Power Service Corp. Abitibi Canyon, Ontario	48,500	150	844,000	5	1932-33
U. S. Engineers Bonneville Dam	48,000	75	3,000,000	2	1937
New York Power & Light Corp. Spier Falls Dev.	47,000	82	1,300,000	1	1930
Beauharnois Light, Heat & Power Co. Beauharnois, P.Q.	46,625	75	1,350,000	3	1932-35
Beauharnois Light, Heat & Power Co. Beauharnois, P.Q.	43,883	75	1,391,000	4	1932-35
Susquehanna Power Company Conowingo, Md.	40,000	82	1,400,000	4	1928
Shawinigan Water & Power Co. Shawinigan Falls, Canada	40,000	138	705,000	1	1922
Shawinigan Water & Power Co.	40,000	138	682,000	1	1928
Shawinigan Water & Power Co.	40,000	138	682,000	1	1929
Alabama Power Company Cherokee Bluffs Dev.	37,500	120	690,000	3	1926
Saltos Del Duero, Spain	37,000	187	1,123,680	3	1932-33
Tennessee Valley Authority Joe Wheeler Power House	36,000	83	1,805,000	2	1936
Safe Harbor Water Power Corp.	35,000	100	1,921,000	1	1934
Tallassee Power Company Badin, N. C.	31,250	156	525,000	1	1922



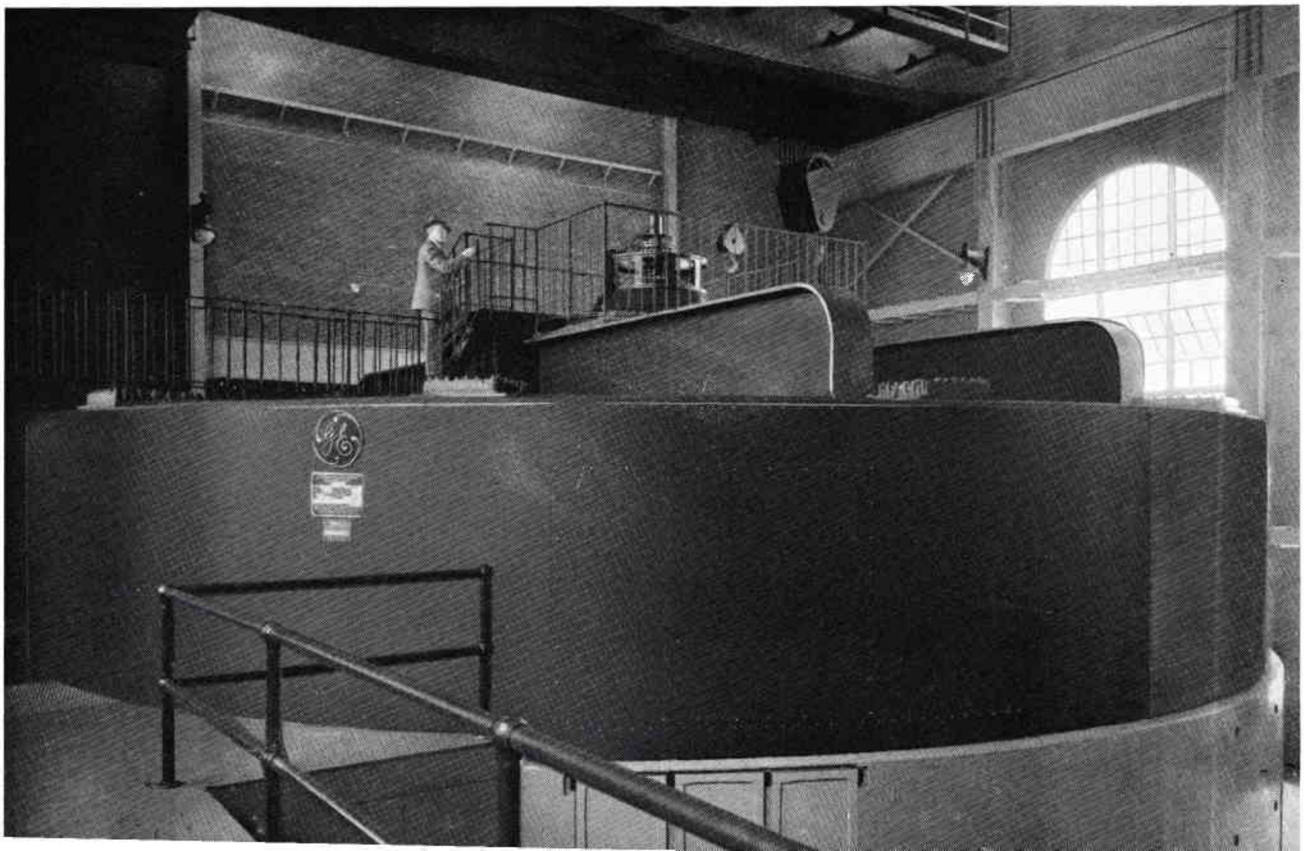
Five waterwheel generators, each rated 77,500 kva, 88 rpm, Dnieper River Development, U.S.S.R.



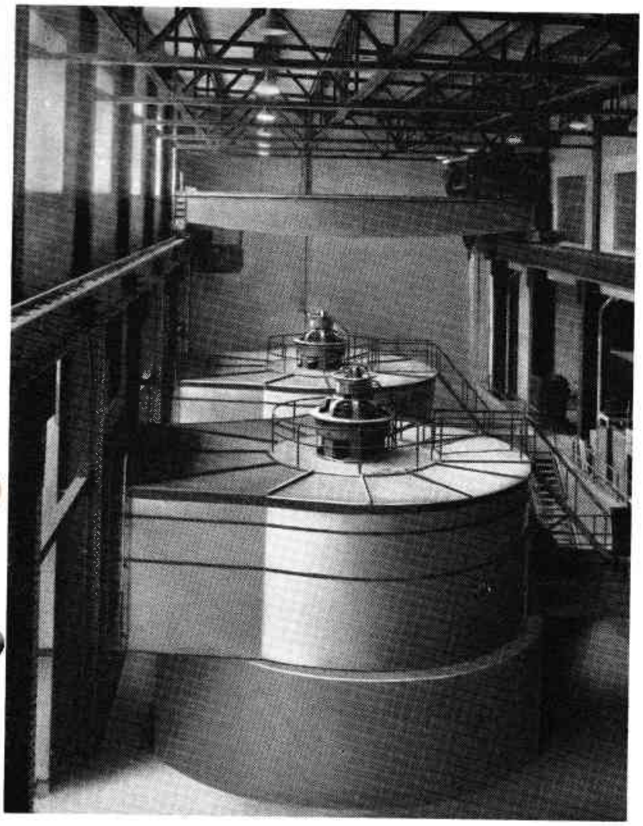
Nine waterwheel generators, five rated 54,000, four rated 45,000 kva, all 187 rpm, Hydro Electric Power Commission of Ontario, Queenston, P. Ont.



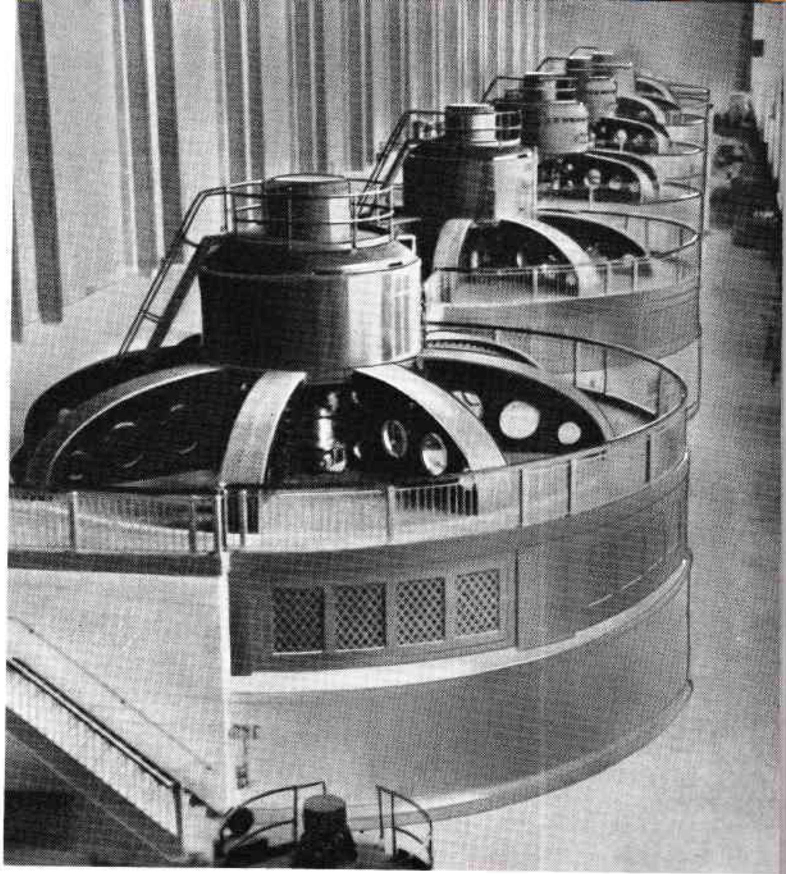
In the background, two 46,625-kva, 75-rpm waterwheel generators, Beauharnois Light, Heat and Power Company, Beauharnois, P.Q.



A 47,000-kva, 8
waterwheel gen
New York Pow
Light Corpora
Spier Falls, N.

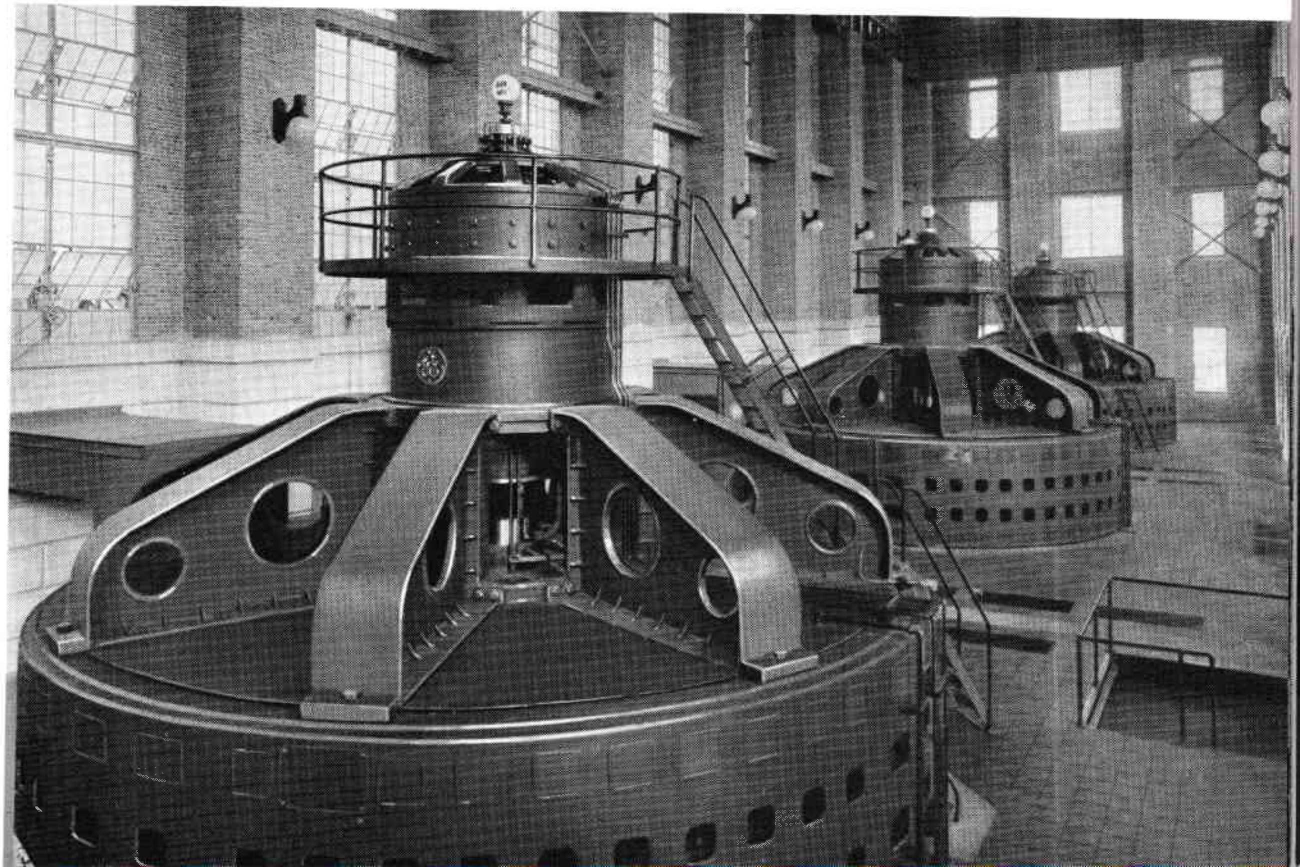


Two 48,500-kva, 150-rpm waterwheel generators, Abitibi Canyon Station, Ontario Power Service Corporation, P. Ont.

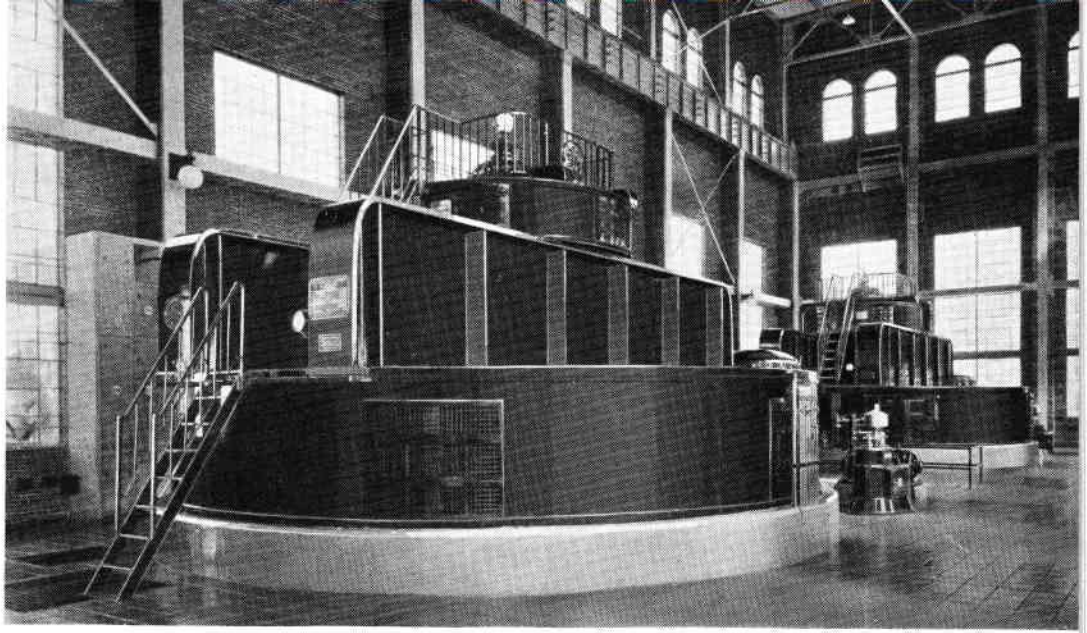


Seven waterwheel generators, four G-E units each rated 40,000 kva, 82 rpm, Susquehanna Power Company, Conowingo, Md.

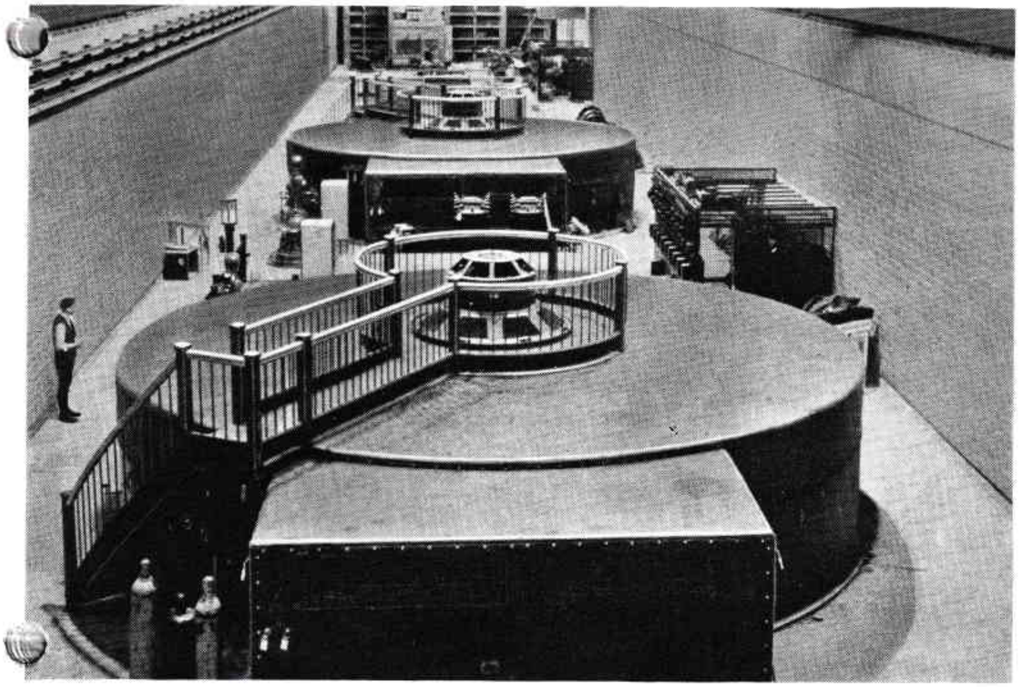
Three 37,500-kva, 120-rpm waterwheel generators, Alabama Power Company, Cherokee Bluffs Development



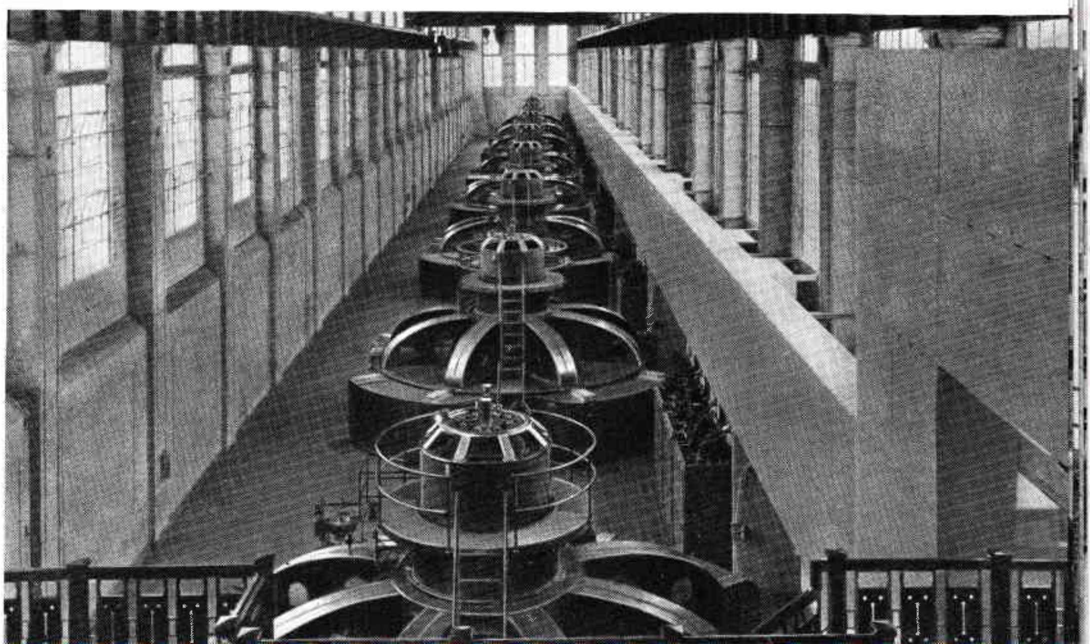
	Generator		Bearing Load	No. of Units	Approx Date of Installation
Purchaser	Kva	Rpm	Pounds		
Washington Water Power Co. Lake Chelan, Spokane, Wash.	30,000	300	361,650	2	1927-28
Nippon Electric Power Co. Japan	30,000	300	477,000	2	1924
Central Maine Power Company	26,667	138	565,000	2	1930
Hidroelectrica Espanola Spain	25,000	375	392,000	3	1930-35
Tallassee Power Company Badin, N. C.	23,160	154	422,000	1	1923
Hidroelectrica Iberica Cinca, Spain	23,000	428	169,000	2	1930
Alabama Power Company Mitchell Dam	20,000	100	640,000	3	1922-23
Showa Power Company Denryoku, Japan	20,000	200	356,000	3	1928
Nippon Elec. Pr. Company, Komaki, Japan	20,000	200/167	350,000	2	1926
Rochester Gas & Electric Co.	19,700	164	365,000	1	1928
Alabama Power Company Tallassee Development, Ala.	19,000	80	645,000	2	1928
Southern Power Company Charlotte, N. C.	18,750	100	497,500	7	1925-26
Powell River Company Powell River, B.C.	18,000	333	248,700	1	1931
City of Los Angeles, Calif.	17,500	428	350,000	2	1920
Cerro de Pasco Copper Corp.	17,000	257	290,000	3	1935-36
Hydroelectrica Espanola Cinca, Spain	17,000	375	260,000	1	1926
Puget Sound Power & Lt. Co. Rock Island Development	16,667	100	1,160,000	4	1931-32
Spruce Falls Power & Paper Co.	16,500	164	301,000	5	1929-31
Hidroelectrica Iberica, Cinca, Spain	15,555	500	124,000	3	1920-25
Hydro-Elec. Power Com. of Ontario, Alexander Dev.	15,000	100	388,000	3	1930
Platte Valley Public Pr. Dist. North Platte, Neb.	14,500	257	216,000	2	1935
Ebro Irrigation & Power Co. Spain Camarasa Dev.	14,060	375	298,000	1	1930
Ebro Irrigation & Power Co. Spain, Camarasa Dev.	14,060	375	298,000	1	1925
Ebro Irrigation and Power Co. Spain, Camarasa Development	14,060	375	240,000	2	1920
Great Northern Power Co. Duluth, Minn.	13,500	360	150,000	1	1919
Northwestern Power & Light	13,333	225	325,000	1	1928



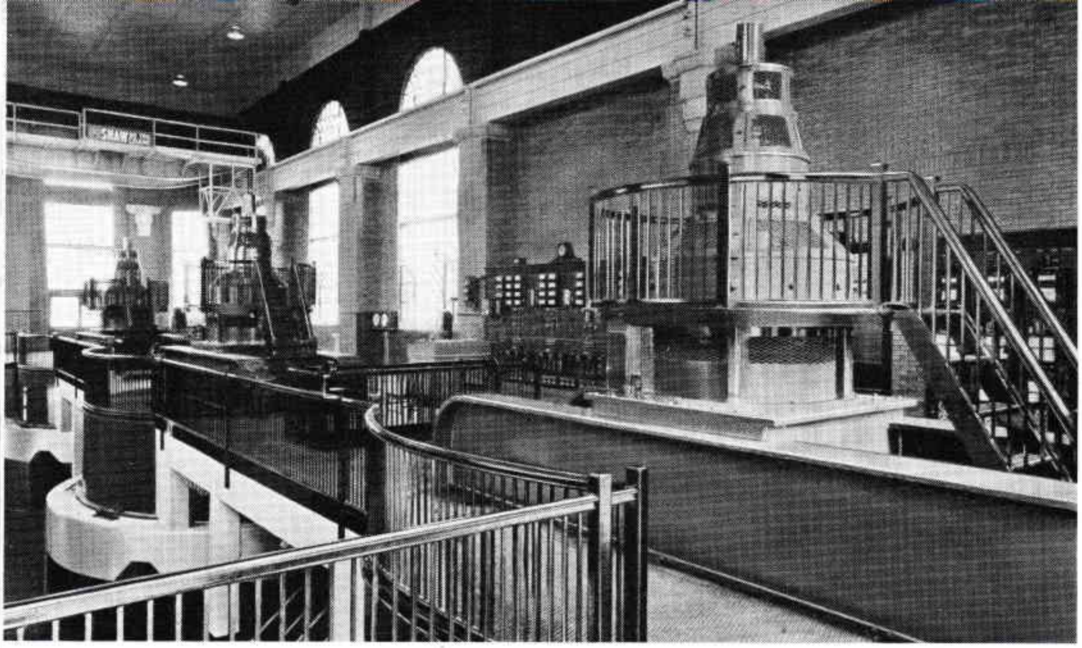
Two 19,000-kva, 80-rpm, waterwheel generators, Alabama Power Company, Tallassee Development, Ala.



Two of four 16,667-kva, 100-rpm waterwheel generators at Rock Island Station of Puget Sound Power and Light Co., Wash.

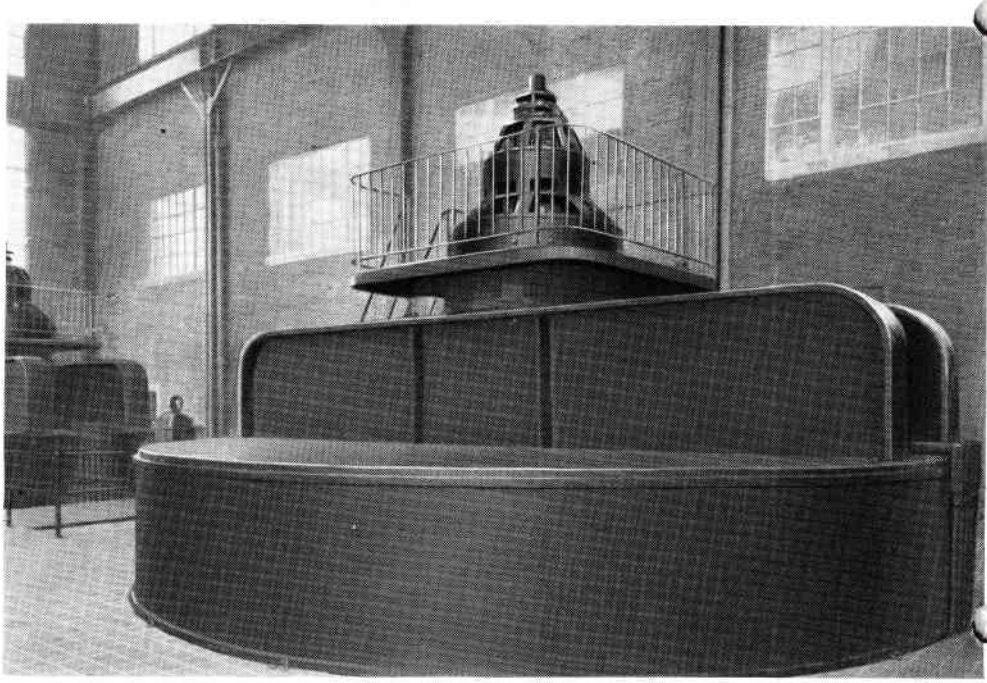


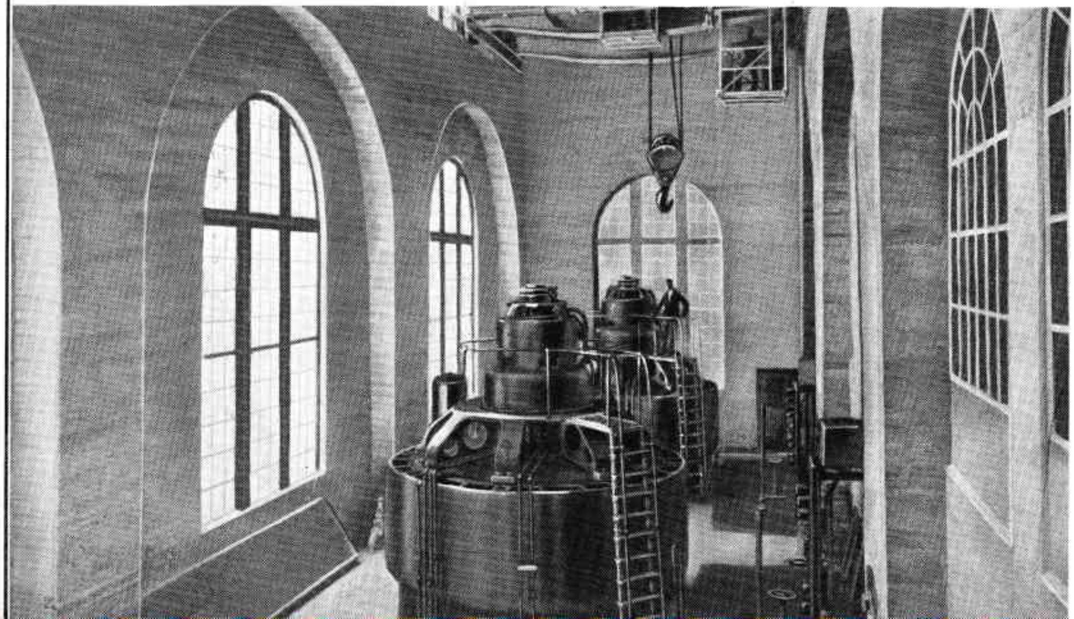
Eight 12,550-kva, 100-rpm waterwheel generators, Louisville Hydroelectric Company, Louisville, Ky.



Three 12,500-kva, 164-rpm waterwheel generators, Hardy Dam Station, Consumers' Power Co., Mich.

Two 12,500-kva, 112-rpm waterwheel generators, New York Power and Light Corp., Conklingville, N. Y.



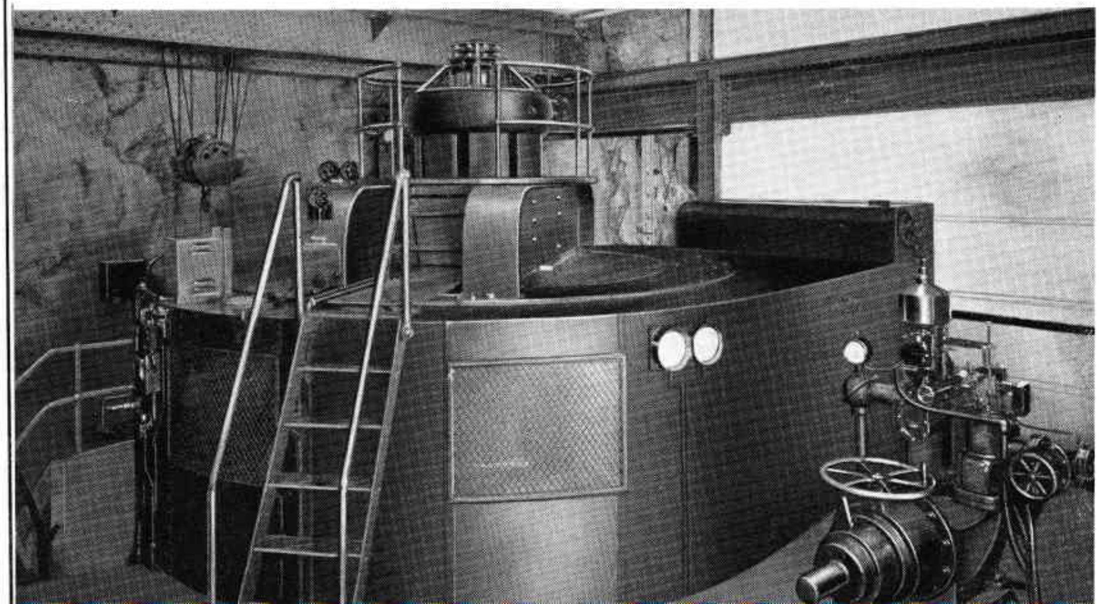


Two 14,060-kva, 375-rpm, waterwheel generators, Ebro Irrigation and Power Co., Camarasa, Spain

Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Salt River Valley Water Users' Association, Ariz.	13,000	150	312,500	1	1930
Kehin Electric Power Co. Japan	13,000	375	210,000	2	1922
Louisville Hydro-Elec. Co. Ohio Falls Development	12,550	100	712,000	8	1928
New York Power & Light Corp. Elmer J. West Station	12,500	112	296,000	2	1930
Cohoes Power & Light Co. Cohoes, New York	12,500	150	225,800	1	1925
Consumers Power Co., Hardy Dam, Oxbow, Michigan	12,500	164	280,000	3	1931
Georgia Railway & Power Co. Tugaloo, Ga.	12,500	171	200,000	4	1921
Pacific Gas & Elec. Co. San Francisco, Calif.	12,500	225	225,000	2	1921
Adirondack Power & Light Corp., Schenectady, N. Y.	12,500	300	180,000	2	1924
St. Lawrence Valley Pr. Co.	12,500	360	146,000	1	1928
Hollinger Gold Mines	12,000	125	317,000	2	1924
Abitibi Electric Dev. Co.	12,000	128	340,000	2	1926
Powell River Power Co.	12,000	250	205,000	1	1926
Societe Generale Des Forces Hydro-electriques du Katanga, Belgian Congo	12,000	375	173,000	1	1929
Washington Water Power Co. Spokane, Washington	11,750	106	375,000	1	1921
Salt River Valley Water Users' Association, Arizona	11,100	300	206,000	3	1925
Tokio Hydro-Electric Co. Japan	10,700	250	256,000	3	1925

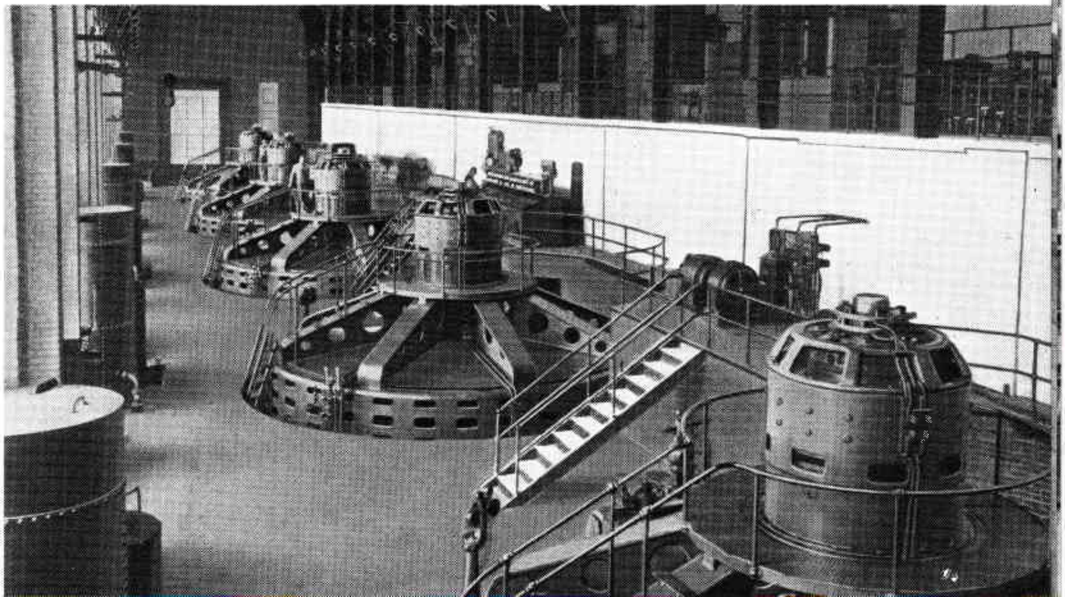
Six 10,000-kva, 86-rpm waterwheel generators, Back River Station, Montreal Island Power Co., P.Q.

Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Hydro-Electric Com. of Ontario Nipigon Development	10,600	120	441,000	4	1924-25
Gifu Electric Power Co., Japan	10,125	257	250,000	3	1925
Montreal Light, Heat & Pr. Co. Inc., Montreal, Canada Cedar Rapids Plant	10,000	55	550,000	8	1918-24
Montreal Island Power Co.	10,000	86	595,000	6	1929
Alabama Power Company	10,000	180	240,000	1	1930
Panama Canal Zone Madden Dam	10,000	214	237,000	2	1935
Great Western Power Co.	10,000	400	250,000	4	1928-29
Shinyetsu Elec. Power Co. Japan	10,000	600	166,000	2	1922
Ganyetsu Denryoku K.K. Japan	9,400	150	406,000	6	1928
Northern N. Y. Utilities Corp. Soft Maple Development	9,375	225	154,000	2	1925
Northern N. Y. Utilities Corp. Oswegatchie Development	9,375	360	150,000	2	1922
East Bay Municipal Utilities Dist. Valley Springs, California	9,375	450	103,500	2	1928
Daido Denryoku K.K., Japan	9,000	150	250,000	2	1926
International Paper Co. Sherman Island Development	9,000	150	200,000	4	1922
Cohoes Light & Power Corp. Cohoes, New York	9,000	180	160,000	1	1921
Braden Copper Co., Chile	8,850	450	151,700	2	1928-29
Tallassee Power Co., Badin, N. C.	8,750	90	260,000	1	1922

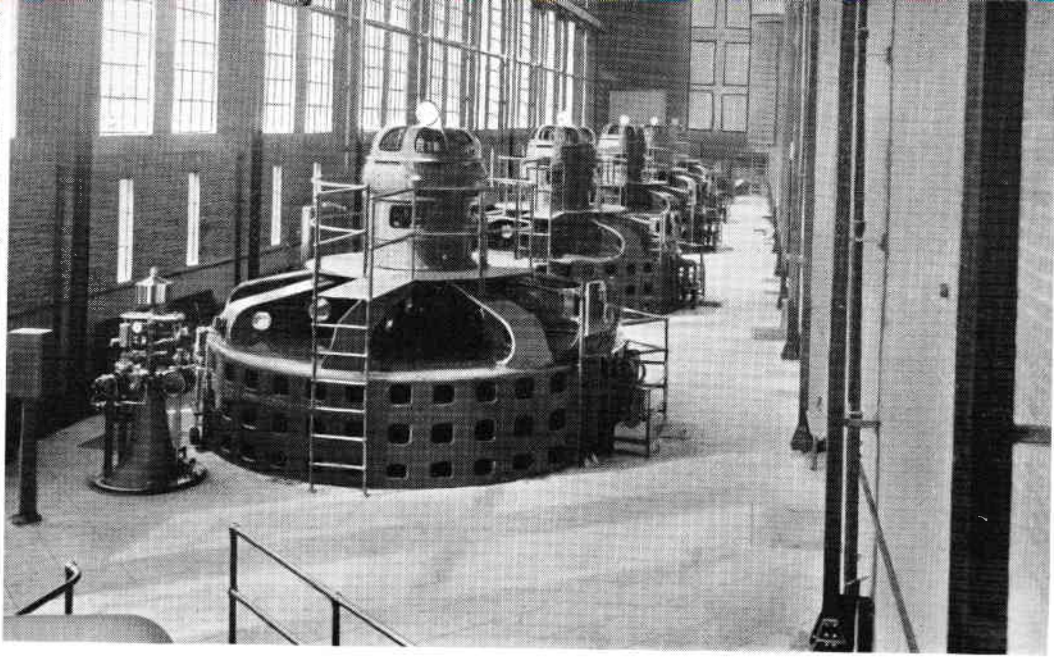


An 8000-kva, 257-rpm waterwheel generator, Spaulding Power House, Pacific Gas and Electric Co.

Purchaser	Generator Kva	 Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Adirondack Pr. & Lt. Corp. Spier Falls Development	8,500	164	170,000	1	1923
Central Maine Power Company	8,000	112	288,000	3	1926
Price Brothers, Chicoutimi Quebec	8,000	189	155,000	2	1922
Pacific Gas & Electric Co.	8,000	257	150,000	1	1928
Wateree Power Company Charlotte, N. C. Fishing Creek Development	7,500	97	276,000	5	1916
Amoskeag Manufacturing Co. Manchester, N. H.	7,500	112	207,500	1	1924
Algoma District Power Co. Michipicoten Harbor, Ont.	7,500	240	157,700	2	1929-30
Hakusan Water Power Company Japan	7,500	514	129,000	2	1925
Adirondack Power & Light Co. Sprite Creek, N. Y.	7,300	600	64,500	1	1923
Beauharnois Const. Company Beauharnois, P.Q.	7,200	180	258,450	2	1932
Beauharnois Power Co.	7,200	180	258,000	2	1932
Tallassee Power Company Badin, S. C.	7,000	90	255,000	2	1919
Tokyo-Hydro-Electric Co. Japan	6,880	250	220,000	3	1925
Amoskeag Manufacturing Co. Manchester, N. H.	6,250	112	205,000	2	1922
Phoenix Utility Co., Brazil Chibarro Station	6,250	450	80,000	1	1930
Green Mountain Power Co.	6,250	600	81,000	1	1926
Kanawha Valley Power Co.	6,150	90	422,000	3	1937
New England Power Company Vernon, Vt.	6,000	75	250,000	2	1921



Five 7500-kva, 97-rpm water-wheel generators, Fishing Creek Plant, Wateree Power Co., Charlotte, N. C.

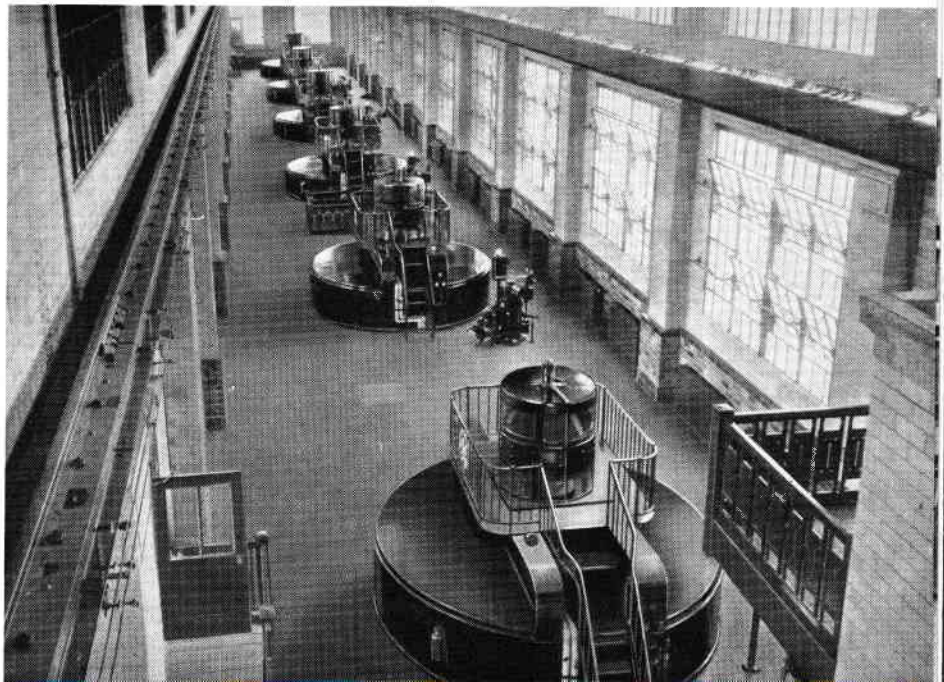


Six 6000-kva, 150-rpm waterwheel generators, Southern Canada Power Co., Hemming Falls, P.Q.

A 5000-kva, 120-rpm waterwheel generator, West Buxton Station, Cumberland County Power and Light Co., Portland, Me.

Two 5000-kva, 400-rpm waterwheel generators, Moshier Creek Station, Northern New York Utilities Co., Croghan, N. Y.

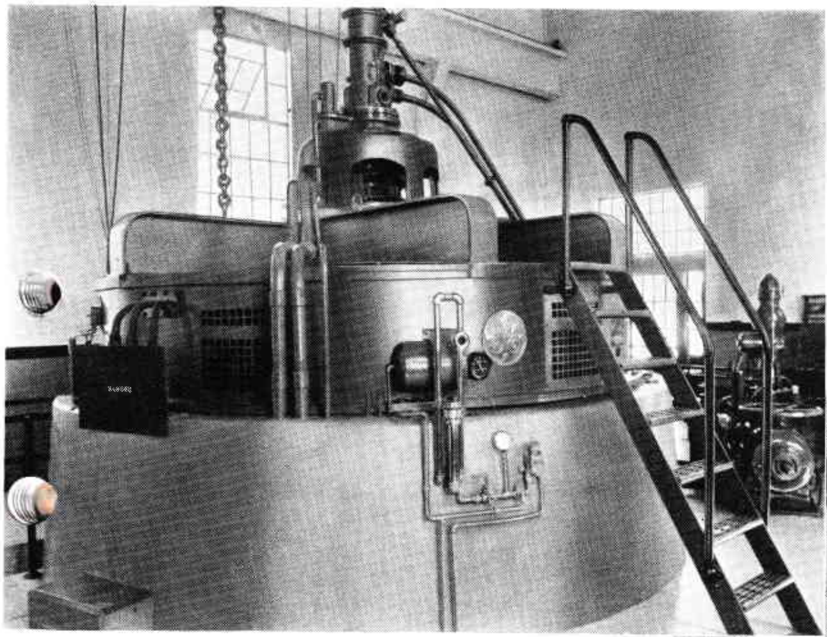
Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Kanawha Valley Power Co.	6,000	90	403,000	6	1935
Southern Canada Power Co.	6,000	150	165,000	2	1924
Southern Canada Power Co.	6,000	150	155,000	4	1924
East Kootaney Power Co.	6,000	360	83,340	2	1923
Northern N. Y. Utilities Norfolk Plant	5,625	164	329,500	1	1927
Gatun Hydro-Elec. Station Panama Canal	5,625	187	117,000	1	1918
Power Commission of Crisp County, Cordele, Ga.	5,000	100	304,000	1	1929
Cumberland County Pr. & Lt. Co. Maine	5,000	120	290,000	1	1927
Beebe Island Corporation	5,000	150	252,000	2	1932
Ebro Irrigation Co., Spain	5,000	167	225,000	2	1930
Turlock & Modesto Irrigation Dist., California	5,000	300	145,000	3	1922
Northern N. Y. Utilities Co. Moshier Creek Station	5,000	400	76,000	2	1928
New England Power Company Searsburg Development	5,000	360	67,000	1	1922
Dept. Rwy. and Canals, Welland Canal, Thorald, Ont.	5,000	360/400	96,500	3	1931
Hydro-Elec. Power Comm. Ranney Falls, Campbellford, Ontario	4,500	120	195,000	2	1921
Northern N. Y. Utilities Corp. Deferiet, N. Y.	4,500	128	128,000	3	1925
Androscoggin Elec. Company Lewiston, Me.	4,500	138	282,000	2	1928
Northern States Power Company Chippewa Falls, Wisconsin	4,500	138	267,500	6	1928



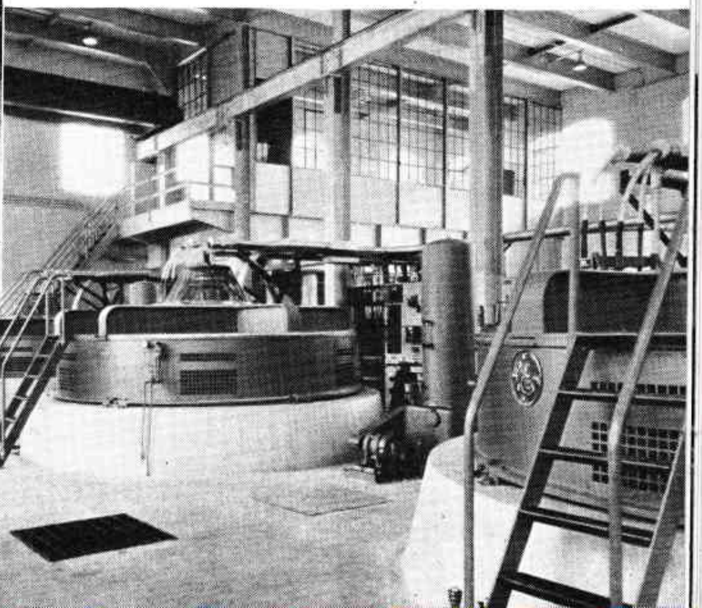
Six 4500-kva, 138-rpm water-wheel generators, Northern States Power Co., Chippewa Falls, Wis.

	Generator		Bearing Load	No. of Units	Approx Date of Installation
Purchaser	Kva	Rpm	Pounds		
International Paper Company Niagara Falls, New York	4,500	300	130,000	2	1919
Consumers Power Company Jackson, Michigan	4,444	90	175,000	2	1918
Braden Copper Company, Chile	4,444	514	225,000	1	1917
Lower Sturgeon Power Co.	4,000	136	125,000	2	1922
Marimbondo Falls Development Brazil	4,000	250	197,000	2	1926
Realty Development Corp. Hillsboro, N. H.	4,000	300	76,000	1	1926
La Cie Hydralique de Portneuf	4,000	360	114,000	1	1925
Ibigawa Electro Chemical Co. Japan	4,000	514	116,000	2	1920
Ibigawa Electro Chemical Co. Japan	4,000	514	44,000	2	1920
Central Maine Power Co. Skowhegan Development	3,750	100	144,000	4	1920-23
Northern Electric Co. Kells, Michigan	3,750	100	93,000	2	1927
Power Corporation of N. Y. Norfolk, N. Y.	3,750	150	250,000	1	1927
Great Northern Paper Co. Millinocket, Me.	3,750	171	174,000	1	1935
Northern N. Y. Utilities Corp. Oswegatchie, N. Y.	3,750	180	85,700	2	1923
Great Northern Paper Co., Dolby Rips, Me.	3,750	240	165,000	1	1930
Public Electric Co. Milton, Vermont	3,750	277	89,000	1	1930
Bathhurst Lumber Company Nipisiquite, N. B.	3,600	300	87,000	2	1922
Bathurst Lumber Company	3,600	300	98,800	1	1929
State of New York, Crescent, N. Y.	3,500	90	190,000	4	1923-24
Alpena Power Co., Alpena, Mich.	3,500	128	95,000	1	1924
City of Los Angeles, Calif. San Fernando Plant	3,500	500	52,500	2	1921
Georgia Railway & Power Co. Seed, Ga.	3,400	225	84,000	2	1926
Consumers Power Company Jackson, Mich. Foote Dev.	3,333	90	150,000	3	1917
Lake Superior Dist. Power Co. Tony, Wis.	3,300	164	80,000	2	1922

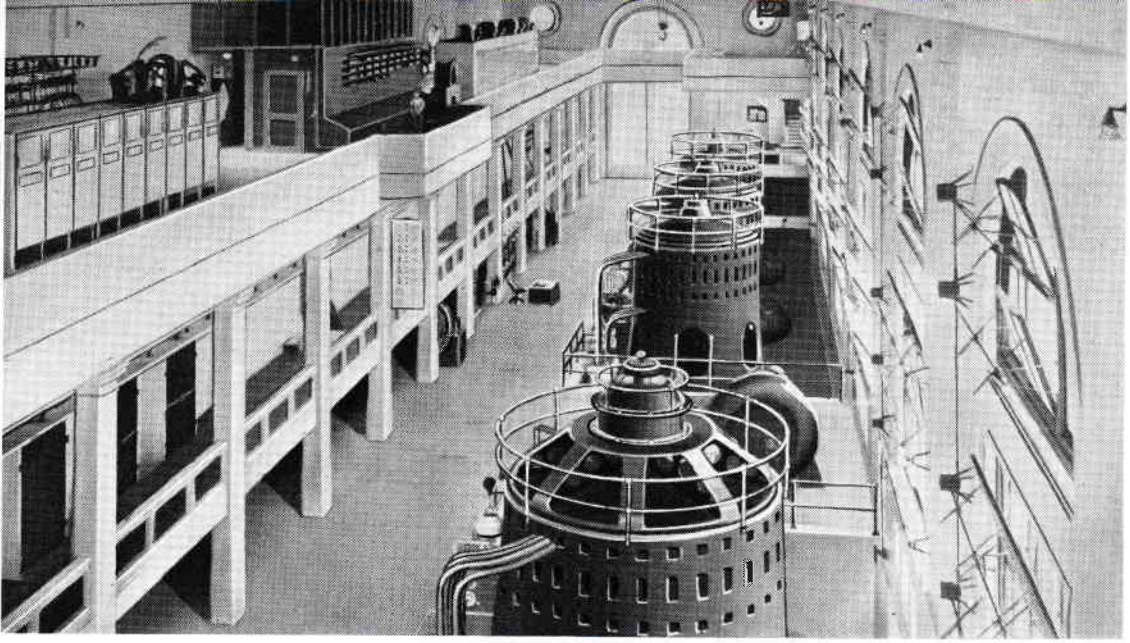
Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Ujigawa Electric Co., Japan	3,300	514	58,000	1	1924
Great Northern Paper Co. Millinocket, Me.	3,250	171	155,000	2	1935
Western N. Y. Utilities Corp. Medina, N. Y.	3,200	250	78,500	1	1923
Public Service Co., Newark, N. J.	3,200	300	85,500	2	1921
Appalachian Elec. Power Co. Reusens Station	3,125	164	124,000	3	1931
Bar Harbor & Union River Power Co. Ellsworth, Me.	3,125	200	61,000	1	1924
South Carolina Gas & Electric Co. Spartanburg, S. C.	3,125	225	77,000	1	1924
Lake Superior Dist. Power Co. Tony, Wis.	3,125	240	59,000	1	1925
Blue Ridge Power Co. Spartanburg, S. C.	3,125	600	38,000	2	1919
Power Commission of Crisp County Cordele, Ga.	3,000	100	144,000	1	1929
Wolverine Power Company Wenigar Station	3,000	138	101,000	2	1934
Texas Hydro Electric Corp.	3,000	180	157,000	3	1931



A 3000-kva, 180-rpm waterwheel generator, Texas Hydroelectric Corp. near Seguin, Texas

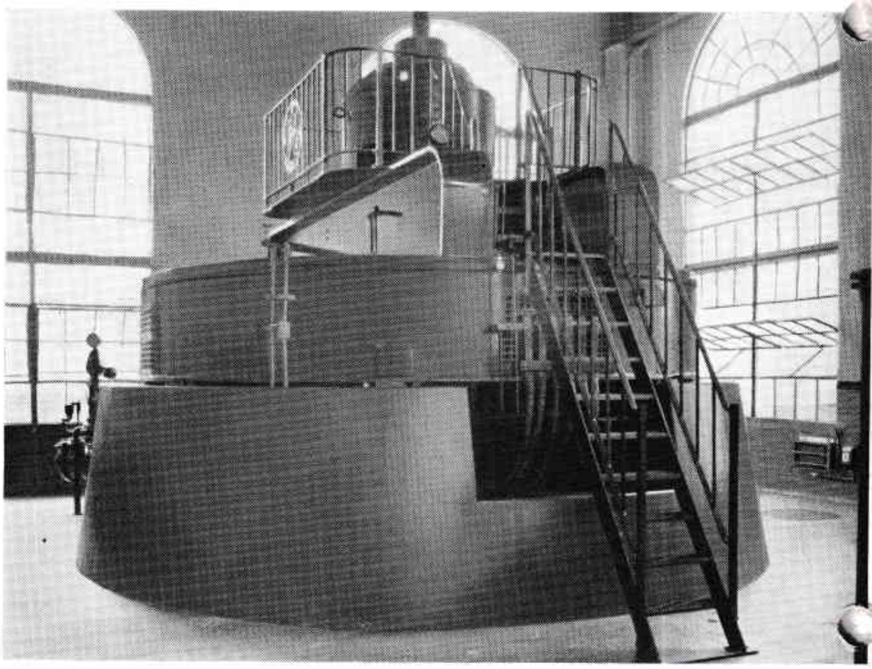


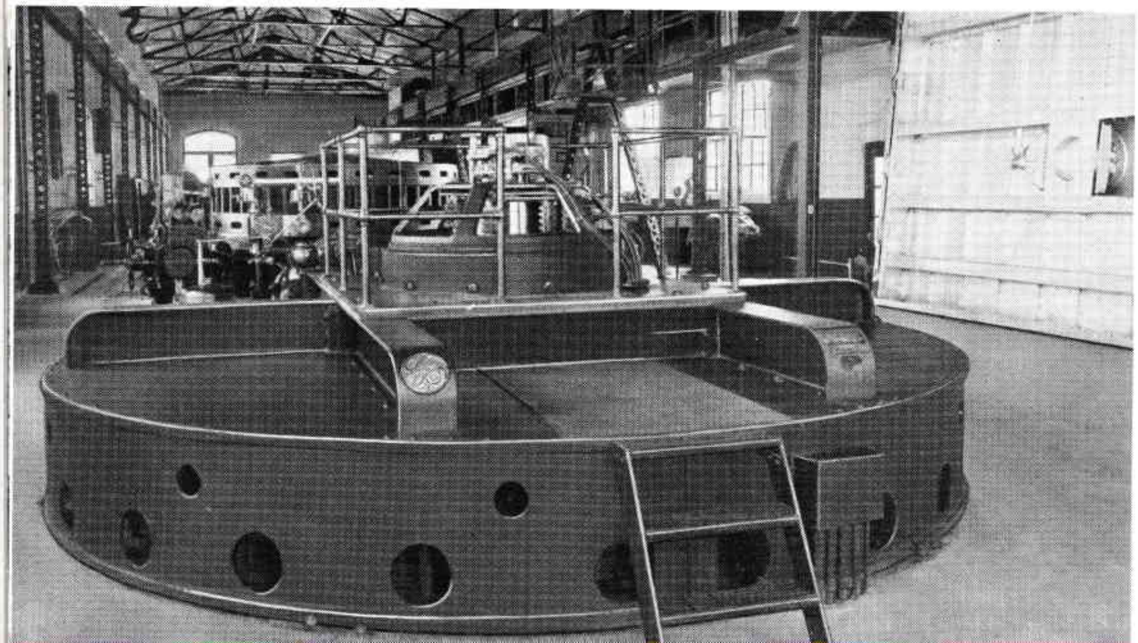
Three 3125-kva, 164-rpm waterwheel generators, Appalachian Electric Power Co., Reusens, Va.



In the foreground, a 5625-kva, 187-rpm generator, and, in the background, three 2500-kva, 250-rpm waterwheel generators, Gatun Hydroelectric Power Station, Canal Zone

A 2500-kva, 120-rpm waterwheel generator, Power Corp. of New York, Norwood, N. Y.

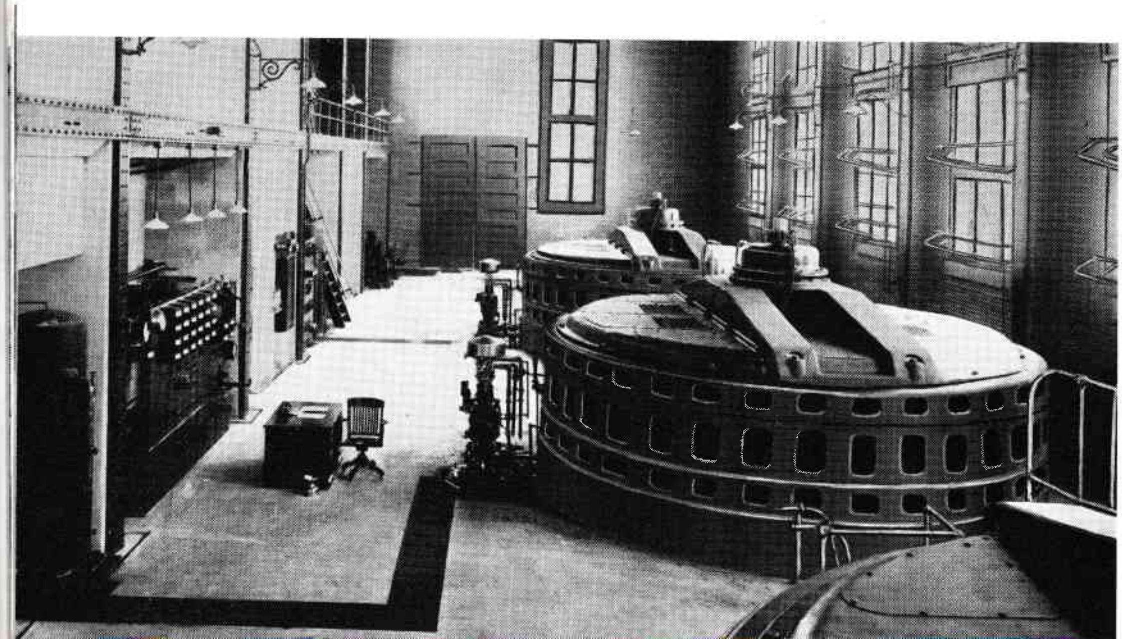




In foreground, a 2500-kva, 128-rpm waterwheel generator, Edison Sault Electric Co. Sault Ste. Marie, Mich.

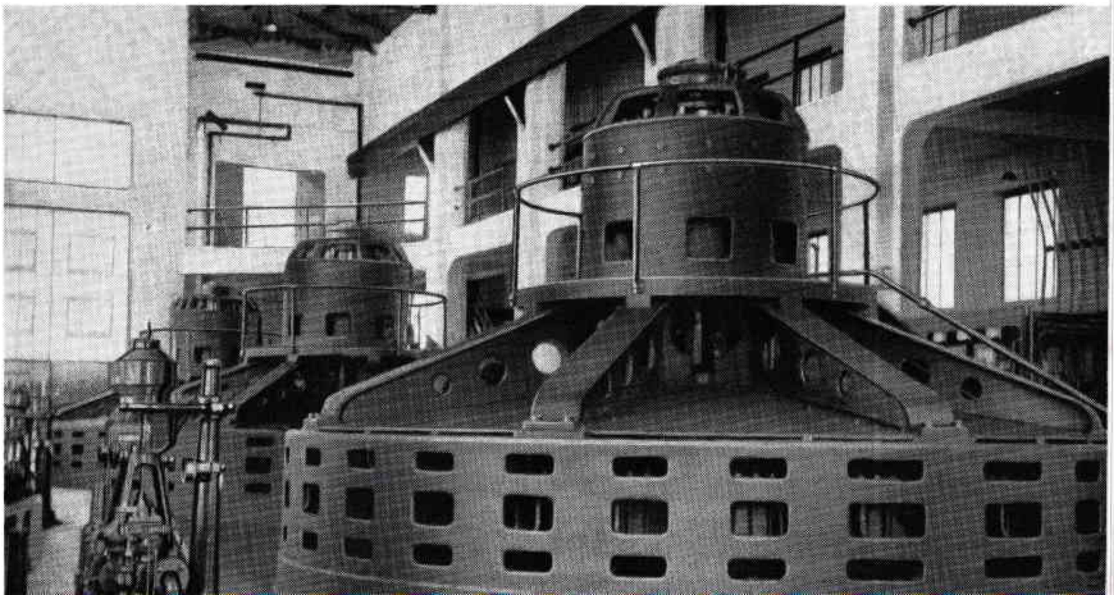
Purchaser	Generator		Bearing Load	No. of Units	Approx Date of Installation
	Kva	Rpm	Pounds		
U. S. Bureau of Reclamation Prosser Power Plant	3,000	200	155,000	1	1932
St. Lawrence Valley Pr. Corp. Potsdam, N. Y.	3,000	225	75,000	2	1925
Dept. of Interior, Bureau of Reclamation, Guernsey Plant	3,000	240	90,000	2	1927
Western N. Y. Utilities Co. Medina, N. Y.	3,000	300	67,000	1	1918
Nova Scotia Pr. Co. St. Margarette Bay, N. S.	2,900	300	90,000	2	1922
New Brunswick Pr. Co., St. John, N. B., Musquash Pr. Dev.	2,900	300	90,000	3	1921
Énergie Électrique Du Sud Quest Mauzac, France	2,857	55	310,000	4	1919
General Development Company Oswego, N. Y.	2,750	128	217,000	5	1926
Spruce Falls Power Co. Kapuskasing, Ont.	2,750	180	72,000	4	1922
Spruce Falls Power Co.	2,750	180	120,000	1	1922
Corporation of Nelson	2,650	240	74,000	1	1928
Kimberly-Clark Company Niagara, Wis.	2,625	240	64,000	1	1916
Northern New York Utilities Co. Watertown, N. Y.	2,500	120	75,000	3	1920
Power Corp. of New York Norwood, N. Y.	2,500	120	182,000	1	1927
Power Corp. of New York Raymondville, N. Y.	2,500	120	182,000	1	1927
Northern Electric Co. Kells, Mich.	2,500	120	100,000	1	1927
Edison Sault Elec. Company	2,500	128	178,000	1	1932
Corporation of Sherbrooke Quebec, Canada	2,500	150	130,800	2	1927
Utah Power & Light Co. Ashton, Idaho	2,500	180	75,000	2	1925
Gatun Hydro-Elec. Station Panama	2,500	250	75,000	3	1913
Virginia Railway & Power Co. Petersburg, Va.	2,500	277	58,400	1	1923
Hiroshima Electric Co., Japan	2,500	450	41,000	1	1927
City of Los Angeles, Calif. Franklin Canyon Plant	2,500	600	45,000	1	1921
E. L. Phillips Co. Keuka, N. Y.	2,500	720	50,000	1	1929

Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Ashton & St. Anthony Power Co. Idaho	2,400	225	80,000	1	1918
Appalachian Power Company Fries, Va.	2,300	97	116,000	3	1915-24
Georgia Alabama Power Co. Albany, Ga.	2,250	88	115,000	3	1921-5
St. Regis Paper Co. Black River, N. Y.	2,250	100	96,000	2	1921
Northern N. Y. Utilities Co. Black River, N. Y.	2,250	100	106,000	1	1922
Wisconsin Valley Elec. Co. Wausau, Wis.	2,250	100	107,000	3	1921-4
Oswego River Power Corp. Oswego, N. Y.	2,250	138	130,000	3	1928
Power Corp. of N. Y. Herrings, N. Y.	2,250	138	139,000	3	1924
Ludlow Manf. Company North Wilbraham, Mass.	2,250	150	90,000	2	1925-33
Green Bay & Miss. Canal Co. Kaukauna, Wis.	2,250	150	125,000	2	1928
Texas Power Corp.	2,250	180	66,000	2	1927
Dryden Pulp & Paper Co.	2,200	164	119,700	1	1928
North Counties Hydro-Elec. Co. Dayton, Ill.	2,100	200	118,000	1	1924
Horseshoe Lumber Co. River Falls, Ala.	2,000	138	90,000	2	1924
Central Maine Power Co. Augusta, Me.	2,000	150	70,000	1	1918
Northern N. Y. Utilities Co. Croghan, N. Y.	2,000	225	50,000	1	1923
Milwaukee Elec. Ry. Co. Milwaukee, Wis.	2,000	300	76,000	1	1915



Three 2300-kva, 97-rpm waterwheel generators, Appalachian Power Company, Fries, Va.

Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Peninsular Power Co. Pine River, Wis.	2,000	360	51,000	2	1921
Beaver River Power Corp. Croghan, N. Y.	2,000	400	42,000	3	1925
Oswego Falls Pulp & Paper Co. Fulton, N. Y.	1,875	65	122,000	3	1915-16
Mond Nickel Co. Canada	1,875	100	142,000	1	1924
Northern Canada Power Co. Timmins, Ontario	1,875	136	72,000	1	1916
Central Maine Power Co. Waterville, Me.	1,875	150	110,000	1	1924
Holyoke Water Power Co. Holyoke, Mass.	1,875	150	86,000	1	1922
Nippon Suiden K. K. Japan	1,850	257	90,000	3	1921
Great Lakes Power Co. Sault Ste. Marie, Ontario	1,800	65	180,000	3	1921
Wisconsin Valley Power Co. Merrill, Wis.	1,750	112	92,000	3	1924
Saranac Pulp & Paper Co. Plattsburgh, N. Y.	1,750	150	92,000	1	1924
Texas Power Corp.	1,750	164	110,000	2	1927
Redlands Water & Power Co. Grand Junction, Colo.	1,750	257	110,000	1	1932
Puget Sound Power & Light Co. Rock Island, Wash.	1,750	300	116,000	1	1931
Kyoto Electric Co., Japan	1,750	300	70,000	2	1919
Escanaba Paper Co. Groos, Mich.	1,700	200	60,000	3	1921
G. E. of South America Rio de Janeiro	1,675	300	80,000	1	1923
J. and J. Rogers Co. Ausable Forks, N. Y.	1,650	400	38,000	1	1926



Three 1875-kva, 65-rpm water-wheel generators, Oswego Falls Pulp and Paper Co., Fulton, N. Y.

Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx. Date of Installation
Greenfield Elec. Lt. & Pr. Co. Shelburne Falls, Mass.	1,625	164	110,000	1	1925
Kanuchuan Power Co. Ilford, Manitoba	1,600	128	114,000	1	1934
Mitsui Company, Japan	1,600	450	47,000	1	1923
Nova Scotia Power Co. French Village, N. S.	1,600	514	41,000	2	1922
Texas Power Corp.	1,550	150	89,000	2	1927
Holyoke Water Power Co. Holyoke, Mass.	1,500	106	77,000	2	1924
Moreau Manuf. Co. Feeder Dam, N. Y.	1,500	120	70,000	5	1922
Virginia Railway & Power Co. Richmond, Virginia	1,500	120	78,000	1	1923
York Haven Water & Power Co. York Haven, Pa.	1,500	120	73,000	1	1924
River Falls Power Co. Ghant, Alberta	1,500	138	74,000	1	1925
Great Northern Paper Co. Anson, Me.	1,500	150	89,000	5	1924
City of Idaho Falls, Idaho	1,500	150	95,000	2	1928-35
Wolverine Power Co. Edenville, Mich.	1,500	200	47,000	1	1925
Alpena Power Co. Alpena, Mich.	1,500	200	45,000	1	1924
Bangor Hydro-Elec. Co. West Enfield, Me.	1,500	200	78,000	2	1927
Village of Morrisville, Vt.	1,500	225	46,000	1	1924
Bibb Manuf. Co. Porterdale, Ga.	1,500	240	45,000	2	1926
International Paper Co. Saranac Lake, N. Y.	1,500	400	42,000	2	1922
St. Lawrence Valley Pr. Co. Eel Weir Power House	1,375	100	136,000	2	1928
Wausau Paper Mills, Wis.	1,375	100	70,000	1	1928
So. N. H. Hydro-Elec. Co. Beecher Falls, Vt.	1,375	164	110,000	1	1927
City of Cookeville, Tenn.	1,375	720	19,000	1	1929
Georgia & Alabama Pr. Co. Albany, Ga.	1,350	164	51,000	1	1920
Central Maine Power Co. Auburn, Me.	1,300	164	43,000	1	1923
South America Gold & Platinum Co.	1,250	72	104,000	2	1923-29
Dominion Textiles Ltd. Magog, Que.	1,250	133	83,000	2	1920

	Generator		Bearing Load	No. of Units	Approx Date of Installation
Purchaser	Kva	Rpm	Pounds		
Northern N. Y. Utilities Corp. Watertown, N. Y.	1,250	150	91,000	2	1925
Montreal Lt. Ht. & Pr. Co., Montreal, Canada, Cedar Rapids Plant	1,250	150	48,500	3	1921-24
Tomahawk Kraft Paper Co. Tomahawk, Wis.	1,250	164	106,000	3	1924
Union Elec. Lt. & Pr. Co.	1,250	164	90,000	1	1927
Florida Power Corp. Dunnellon, Fla.	1,250	164	90,000	1	1926
Saranac Pulp & Paper Co. Plattsburg, N. Y.	1,250	180	64,500	1	1924
Keith Paper Co. Turners Falls, Mass.	1,250	225	42,000	1	1918
Portland Ry. Lt. & Pr. Co. Portland, Oregon	1,250	240	45,000	1	1924
North Counties Hydro-Electric Co. Dayton, Ill.	1,250	257	81,000	2	1924
City of Martinsville, Va.	1,250	300	63,000	1	1931
Orange County Public Service Co. Middletown, N. Y.	1,250	360	36,000	4	1922-25
City of Rochester, Minn.	1,150	225	34,500	2	1918
City of Allegan, Mich.	1,125	120	110,000	1	1935
Canadian Cottons, Ltd. Cornwall, Ont.	1,125	144	83,000	3	1921
Strathmore Paper Co.	1,125	180	44,000	1	1930
Village of Swanton, Vt.	1,125	360	40,000	1	1929
Arrowhead Mills Fulton, N. Y.	1,020	150	50,000	2	1918-19
Nashua Manuf. Co., N. H.	1,000	100	63,000	2	1920
Corp. of Hull, Quebec	1,000	100	60,000	1	1917
Idaho Power Co., Boise, Idaho, Swan Falls Plant	1,000	109	51,500	4	1918
St. Louis River Pr. & Improvement Co., Cloquet, Minn.	1,000	120	80,000	3	1922
Little Falls Water Pr. Co. Minn.	1,000	120	75,000	2	1920
West Missouri Power Co. Osceola, Missouri	1,000	120	105,000	2	1927
Fulton Lt. Ht. & Pr. Co. Fulton, N. Y.	1,000	150	70,000	1	1924
Sibley Manuf. Co. Augusta, Ga.	1,000	164	50,000	1	1921
Marathon Paper Mills	1,000	200	75,000	1	1926

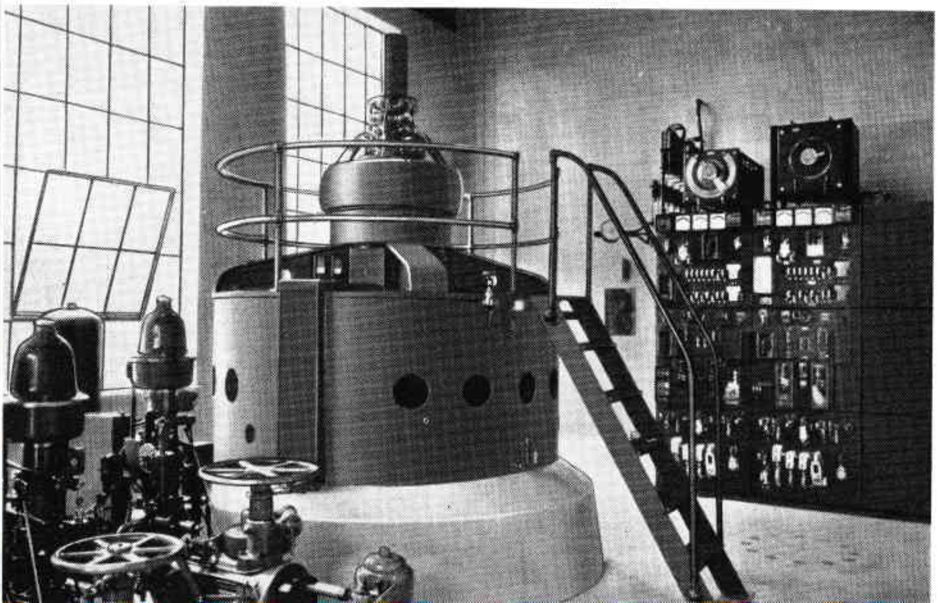
Purchaser	Generator		Bearing Load	No. of Units	Approx Date of Installation
	Kva	Rpm	Pounds		
Chemical Paper Manuf. Co. Holyoke, Mass.	1,000	200	68,000	2	1935
Millstead Manuf. Co., Ga.	1,000	225	70,000	1	1924
Auburn Woolen Mills	1,000	257	57,000	1	1932
Androscoggin Mills Lewiston, Me.	1,000	257	34,000	1	1925
Grafton County Lt. & Pr. Co. Lebanon, N. H.	1,000	360	33,000	1	1921
Melones Mining Co., Calif.	1,000	360	24,000	1	1920
Churchill River Pr. Co. Manitoba	1,000	400	48,000	2	1929
U. S. Reclamation Service Shoshone Project	1,000	600	28,000	2	1921
J. & J. Rogers Ausable Forks, N. Y.	1,000	600	18,000	1	1930
Cuyuna Range Pr. Co. Pillager, Minn.	950	120	46,000	2	1917
Wayne County Pumping Station Detroit, Mich.	940	360	50,000	3	1931
Northern N. Y. Utilities Co. Croghan, N. Y.	937	257	30,000	2	1916
Sherbrooke Land & Pr. Co.	900	180	79,000	2	1927
Wyoming Valley Paper Co.	875	100	90,000	1	1935
Malone Lt. & Pr. Co., N. Y.	875	100	90,000	1	1930
Penobscot Mills Howland, Me.	875	100	40,000	1	1924
Twin State Gas & Elec. Co. Passumpsic, Vt.	875	120	50,000	1	1929
Bangor Hydro-Elec. Co. Veazie Station	875	128	54,000	1	1934
Beaverton Pr. Co., Mich.	875	138	54,600	1	1920
Wisconsin Pr. & Lt. Co.	875	150	70,000	1	1927
City of Marquette, Mich.	875	180	42,000	1	1924
Auburn Woolen Mills Auburn, N. Y.	875	257	57,000	1	1932
Valley Paper Co. Holyoke, Mass.	875	277	51,000	1	1932
Village of Barton, Vt.	875	514	19,000	1	1931
Newton Falls Paper Co. Watertown, N. Y.	850	144	42,000	1	1918
Kentucky Hydro-Elec. Co.	850	150	90,000	3	1927
Canadian Cottons, Ltd. Milltown, N. B.	812	150	61,000	3	1920
Virginia Western Power Co. Balcony Falls, Virginia	800	90	73,000	3	1916

Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Pacific Mills Lawrence, Mass.	800	100	85,000	4	1923
Kitahara Hydro-Elec. Co. Japan	800	600	16,000	2	1920
Howland Pulp & Paper Co. Howland, Me.	780	120	51,500	2	1918
Montreal Cottons, Ltd. Valley Field, Que.	750	90	78,000	1	1921
City of Idaho Falls, Idaho	750	100	46,000	1	1920
Corp. of Hull	750	100	40,000	1	1922
Rockford Elec. Co., Ill.	750	100	75,000	2	1924
Michigan Pub. Service Co. Boardman River Plant No. 2 Traverse City, Mich.	750	112	74,000	1	1930
Harpers Ferry Elec. Lt. & Pr. Co. Harpers Ferry, W. Virginia	750	120	55,000	1	1925
Page Power Co. Luray, Va.	750	138	42,000	2	1926
Enterprise Manuf. Co. Augusta, Ga.	750	164	40,000	2	1921
Northeastern Pr. Co. West Union, Iowa	750	164	75,000	1	1925
Landa Lt. & Pr. Co. New Braunfels, Texas	750	180	44,500	1	1924
Eastern Iowa Pr. Co. Maquoketa, Iowa	750	180	55,000	2	1924
W. S. Libbey Company Lewiston, Me.	750	200	32,000	1	1928
Rocky Mount Mills, N. C.	750	200	37,000	1	1924
City of Richmond, Va.	750	200	50,000	2	1924
Page Power Co., Stanley, Va.	750	200	55,000	1	1925
Town of Andrews, N. C.	750	225	32,000	2	1924
Georgia Ala. Pr. Co. Albany, Ga.	750	225	30,000	1	1920
Village of Morrisville, Vt.	750	257	35,000	1	1924
Newton Falls Paper Co., N. Y.	750	400	28,000	2	1927
Corp. of Sherbrooke	725	120	72,000	1	1927
Chapin & Gould Paper Co. Russell, Mass.	700	225	40,000	1	1924
Bangor Ry. & El. Co., Maine	675	90	55,000	1	1914
U. S. Government Minidoka Project No. 1, Idaho	640	450	25,000	1	1931
St. Lawrence Valley Power Corp. Eel Weir Power House	625	100	57,000	1	1928

Purchaser	Generator		Bearing Load	No. of Units	Approx Date of Installation
	Kva	Rpm	Pounds		
American Thread Co. Willimantic, Conn.	625	112	55,000	1	1924
People's Gas & Electric Co. Oswego, N. Y.	625	120	41,000	1	1919
Holyoke Water Power Co. Holyoke, Mass.	625	150	42,000	1	1921
Continental Bag & Paper Co. York Haven, Pa.	625	164	70,000	1	1926
Sullivan Machinery Co Claremont, N. H.	625	200	40,000	1	1927
Spray Cotton Mills, N. C.	625	200	29,000	1	1930
Millville Manuf. Co.	625	200	40,000	1	1929
Cuba Electric Co.	625	200	43,000	1	1927
Rocky Mount Mills Rocky Mount, N. C.	625	200	33,000	2	1924
Smoky Mountain Power Co. Bryson City, N. C.	625	225	30,000	1	1930
Strathmore Paper Co. Mittineague, Mass.	625	240	30,000	1	1930
Lake Sunapee Power Co. Sunapee Depot, N. H.	625	257	30,000	1	1924
Belton Power Co., S. C.	625	257	30,000	1	1924
Burford, Hall & Smith Spartanburg, N. C.	625	400	25,000	2	1926
U. S. Reclamation Service Yuma, Arizona	625	450	22,000	1	1921
Grafton County Elec. Lt. & Pwr. Co. Lebanon, N. H.	625	514	32,000	1	1922
Sendai Elec. Co., Japan	600	360	42,000	2	1919
G.E.S.A., Argentine	590	214	11,000	1	1926
U.G.I. Contracting Co. Baldwinsville, N. Y.	570	94	30,000	2	1926
Indiana & Mich. Elec. Co.	563	128	41,000	4	1927
Rock Fish Mills, Hope Mills, N. C.	563	164	43,000	1	1930
City of Alleghan, Mich.	563	180	55,000	1	1935
Twin States Gas & Elec. Co. Hoosick Falls, N. Y.	563	257	37,000	1	1928
Pittsburg Plate Glass Co. Crystal City, Missouri	560	68	32,000	8	1924
Sendai Elec. Co., Japan	600	180	31,000	2	1920
Town of Bryson City, N. C.	600	225	30,000	1	1925
Smith Paper Co. Lenoxdale, Mass.	600	225	30,000	2	1924
Dwight Manuf. Co. Chicopee, Mass.	600	240	29,000	3	1921

Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Oswegatchie Paper Co. Gouverneur, N. Y.	525	200	40,000	1	1924
Digby County Power Board	520	514	29,100	1	1931
Union Bag & Paper Corp. Sheboygan, Mich.	500	90	58,000	2	1921–23
Montreal Cottons, Ltd. Valley Field, Que.	500	100	50,000	4	1919
Twin States Gas & Elec. Co. St. Johnsbury, Vt.	500	112	45,000	1	1920
Continental Mills Lewiston, Maine	500	120	50,000	3	1921
Derby Gas Co., Derby, Conn.	500	120	45,000	1	1921
Berwick & Salmon Falls Elec. Co. So. Berwick, Maine	500	133	30,000	3	1918
Tait Paper Co. Plattsburg, N. Y.	500	150	18,000	1	1925
Edwards Manuf. Co. Augusta, Maine	500	150	30,000	1	1927
Regent Knitting Mills	500	164	47,000	1	1929
Everett Mills Lawrence, Mass.	500	164	26,000	1	1921
Page Power Co. Luray, Va.	500	164	43,000	1	1927
Atlantic Public Utilities Co. Caribou, Maine	500	164	43,000	2	1927
Clifton Manuf. Co., S. C.	500	180	32,000	1	1929
Juan Garcia Co., Spain	500	187	38,000	1	1918
Northeastern Iowa Power Co. West Union, Iowa	500	200	30,000	1	1925
Page Power Co. Stanley, Virginia	500	200	43,000	2	1921
Claremont Paper Co. Claremont, N. H.	500	200	20,000	2	1921
Northern Mich. Public Service Co.	500	200	40,000	1	1926
Twin States Gas & Elec. Co.	500	200	18,000	1	1934
Gothenburg Lt. & Pr. Co., Neb.	500	300	30,000	1	1927
Salt River Valley Water Users' Asso. Arizona	500	500	26,000	1	1924
Southern Berkshire Pr. & Elec. Co.	500	514	13,000	1	1921
Auxiliary Eastern Canal	480	500	10,000	2	1925
U. S. Army Springfield, Mass.	470	257	22,000	1	1920
Athol Gas & Elec. Co. Farley, Mass.	450	120	38,000	1	1921

Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Mass. Cotton Mills Lowell, Mass.	450	138	32,000	3	1917
Malone Pr. & Lt. Co. Malone, N. Y.	450	164	43,000	1	1926
Chapin & Gould Paper Co. Huntington, Mass.	450	200	27,000	1	1921
Continental Mills Lewiston, Me.	438	128	35,000	1	1925
City of Bangor, Maine	438	180	52,000	1	1931
Paul A. Sorg Paper Co.	438	180	28,000	1	1927
Whiting & Co. Holyoke, Mass.	438	200	30,000	1	1928
City of Petoskey, Mich.	438	225	20,000	1	1933
Bangor Ry. & Elec. Co. Muchias, Me.	438	225	18,000	1	1925
Franklin N. H. Lt. & Pr. Co.	438	257	29,000	2	1924
Cornish & Kezar Falls Lt. & Pr. Co.	438	257	30,000	1	1927
Twin States Gas & Elec. Co.	438	257	30,000	1	1928
Alexander Pirie & Sons, Ltd. Glasgow, Scotland	425	200	21,900	1	1921
Pittsburgh Plate Glass Co. Crystal City, Missouri	415	106	30,000	8	1924
Bangor Ry. & Elec. Co., Maine	400	150	27,300	1	1921
Elk Electric Co. Elk Rapids, Mich.	375	100	48,000	1	1924
Department Ry. & Canals Cote, St. Paul	375	106	55,400	1	1928
Worumbo Manuf. Co. Lisbon Falls, Me.	375	120	28,600	2	1921–29
Tremont & Suffolk Mills Lowell, Mass.	375	120	27,700	2	1921
City of Thief River Falls, Minn.	375	128	37,000	1	1927
Twin State Gas & Elec. Co. St. Johnsbury, Vt.	375	138	29,000	1	1920



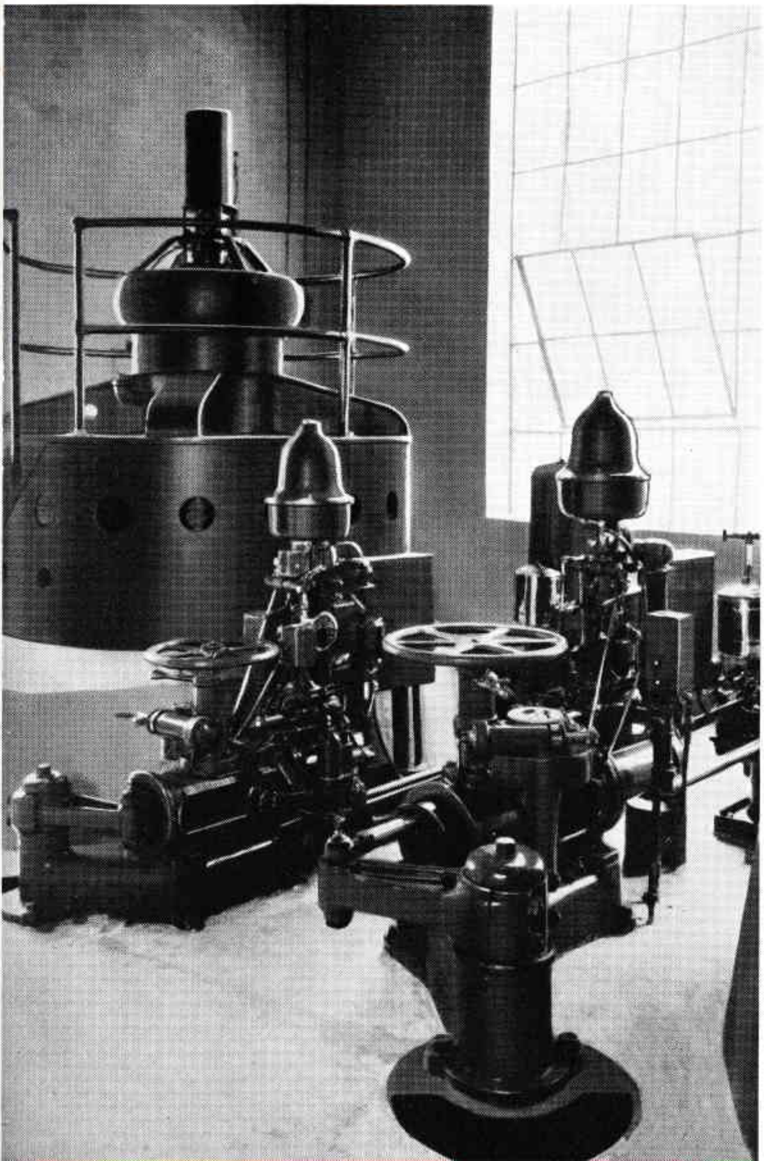
A 438-kva, 225-rpm water-wheel generator, Municipal Plant of City of Petoskey, Mich.

Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Cabot Manufacturing Co. Brunswick, Me.	375	138	28,000	3	1921
Power Constr. Co. Worcester, Mass.	375	138	27,000	3	1924
Middle West Utilities Co. Goshen, Ind.	375	150	36,000	2	1924
Iroquois Utility Co. Gowanda, N. Y.	375	200	30,000	1	1928
Wisconsin Pr. & Lt. Co.	375	200	30,000	1	1929
City of Crystal Falls, Mich.	375	200	30,000	1	1925
Bethlehem N. H. Elec. Co.	375	200	30,000	1	1925
Buckeye Lt. & Pr. Co. Covington, Ohio	375	200	29,200	1	1921
Bowersock Mills Pr. Co. Lawrence, Kansas	375	225	30,000	2	1925
Eugene, Oregon, Woolen Mills	375	225	31,000	1	1928
Putnam, Conn., Woolen Co.	375	225	18,500	1	1925
Town of Littleton, N. H.	375	257	29,000	1	1935
United Paper Board Co. Thomson, N. Y.	375	257	31,000	1	1925
Midvale Paper Board Co. Rossman, N. Y.	375	277	25,000	1	1928
Stonewall Pr. Co. Manassas, Va.	375	277	30,000	1	1928
International Paper Co. Ticonderoga, N. Y.	375	277	20,000	1	1923
Juliette Georgia Milling Co.	375	277	31,000	1	1926
R. F. Lenhardt, Norris, S. C.	375	300	30,000	1	1925
City of Martinsville, Va.	375	377	19,000	1	1932
Methuen Co., Methuen, Mass.	356	327	27,000	1	1921
Twin States Gas & Elec. Co. Gorham, N. H.	350	100	30,000	2	1918
Penmans, Ltd.	325	180	25,500	2	1929
Atlas Plywood Co. East Berkshire, Vermont	312	100	32,000	1	1925
Warren Pr. Co. Front Royal, Virginia	312	112	42,000	1	1928
Wisconsin Pr. & Lt. Co. Janesville, Wis.	312	120	45,000	2	1926
Republic Service Corp.	312	138	43,000	2	1930
Village of Union City, Michigan	312	150	43,000	1	1924

Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
City of Ft. Wayne, Ind.	312	150	43,000	1	1925
City of Thief River Falls, Minn.	312	150	43,000	1	1927
Walling Lt. & Pr. Co. McMinnville, Tenn.	312	164	27,000	1	1923
Rogers Fibre Co. Kennebunk, Me.	312	164	23,000	1	1923
Ozark Utilities Co. Humansville, Missouri	312	164	31,000	1	1925
Asbestos Corp. of America Hyde Park, Vt.	312	180	21,600	1	1921
Great Lakes Power Co. Caro, Mich.	312	180	41,000	1	1925
Town of Shenandoah, Virginia	312	180	31,000	1	1925
Twin States Gas & Elec. Co. Centervale, Vermont	312	180	23,000	1	1928
E. E. Hilliard Co. Buckland, Conn.	312	180	17,000	1	1928
U. S. War Dept. Lock & Dam No. 15, Mississippi River	312	180	35,000	1	1933
Corp. of Buckingham, Que.	312	200	25,000	2	1924
American Writing Paper Co. Windsor Lake, Conn.	312	225	17,000	1	1922
Everett Mills Lawrence, Mass.	312	225	14,800	2	1921
Chapin & Gould Paper Co. Huntington, Mass.	312	257	19,000	1	1921
Great Falls Manuf. Co. Somersworth, N. H.	312	257	14,800	1	1921
Bala Electric Co.	312	277	23,500	1	1925
Village of Springville, N. Y.	312	300	25,000	2	1924–26
Gladwin Lt. & Pr. Co., Mich.	312	300	30,000	1	1925
G.E.S.A. Brazil	312	300	32,000	1	1927
Tremont & Suffolk Mills Lowell, Mass.	300	128	32,000	1	1918
Boston Duck Co. Bondsville, Mass.	300	200	16,500	3	1917
Village of Eagle River, Wis.	278	112	33,000	1	1927
E. I. DuPont De Nemours & Co. Newhall, Me.	260	300	14,000	1	1929
Board of Water & Elec. Lt. Comm. Lansing, Mich.	250	120	36,000	1	1936
City of Waverly, Iowa	250	138	43,000	1	1924
Suburban Lt. & Pr. Co. Malta, Ohio	250	138	43,000	1	1928

	Generator		Bearing Load	No. of Units	Approx Date of Installation
Purchaser	Kva	Rpm	Pounds		
Virginia Cotton Mills Swepsonville, N. C.	250	150	43,000	1	1928
Montreal Cottons	250	150	28,400	3	1924
Woodsville, N. H., Fire Dist.	250	171	24,000	1	1935
Tait Paper Industries Plattsburg, N. Y.	250	225	16,000	1	1925
J. D. Dunn, Huntington	250	240	21,000	1	1925
Blake & Higgins Co. Bellows Falls, Vt.	250	257	30,000	1	1930
Lincoln Paper Mills	225	300	20,000	1	1920
U. S. Bobbin & Shuttle Co. Goffstown, N. H.	219	128	24,000	1	1924
American Powder Mills Maynard, Mass.	219	138	23,000	1	1924
Rockville-Willimantic Lighting Co. Willimantic, Conn.	219	150	20,000	1	1924
Back Bros. Flour Mills Beatrice, Neb.	219	150	26,000	1	1924
Community Pr. & Lt. Co. St. Louis, Mo.	219	180	21,000	1	1925
L. K. Green El Dorado Springs, Mo.	219	180	25,000	1	1925
Thomson-Weinman & Co.	219	180	25,000	1	1934
West Bend, Wisconsin, Heating & Lighting Co.	219	200	22,000	1	1926
George W. Prentiss & Co. Holyoke, Mass.	219	200	12,400	1	1930
City of Waverly, Iowa	219	200	21,000	1	1928
Village of Union City, Mich.	210	180	20,000	1	1922
Delta Canal	205	225	19,000	1	1927
Senoso Paper Co., Phoenix, N. Y.	200	187	23,000	2	1925
Iona Water Pr. & Elec. Co.	187	128	21,000	1	1925
Lisbon, N. H., Lt. & Pr. Co.	187	138	17,000	1	1929
Cherokee, N. C., Indian School	187	138	21,000	1	1923
Sevierville, Tenn. Lt. & Pr. Co.	187	150	20,000	1	1928
Town of Kennebunk, Me.	187	150	11,000	1	1928
Burkhart Milling & Elec. Pr. Co. Hudson, Wis.	187	150	18,000	1	1924
Fellows Gear Shaper Co. Springfield, Vt.	187	164	15,000	1	1928
Germania Mills, Holyoke, Mass.	187	164	15,000	2	1929
Riverside Lt. Pr. & Gas Co. Florence, Kansas	187	180	16,000	1	1923

Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Crete, Neb., Mills	187	200	20,000	1	1930
Martin Pulp & Paper Co.	187	200	20,000	1	1929
Corp. of Enosburg Falls, Vt.	187	225	13,000	1	1928
Central Conn. Pr. & Lt. Co. East Haddam, Conn.	187	257	11,000	1	1926
City of Petoskey, Mich.	187	360	7,700	1	1933
Enterprise Manuf. Co. Ramseur, N. C.	180	225	11,000	1	1924
East Providence Water Co. Rumford, R. I.	180	225	11,000	1	1924
Auxiliary Eastern Canal	160	750	9,500	2	1925
New England Spun Silk Corp.	156	128	18,000	1	1926
Franklin Process Spinning Mill	156	128	18,000	1	1926
Humboldt, Kansas, Lt. & Pr. Co.	125	128	18,000	1	1923



Purchaser	Generator Kva	Generator Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Columbia Narrow Fabric Co.	125	138	18,000	2	1923–4
Walter Baker & Co. Milton, Mass.	125	150	11,000	3	1923
Woonsocket Falls Mills	125	150	25,000	1	1929
Southern Counties Pr. Co. Belleville, Wis.	125	164	10,000	1	1924
Assawaga Co. Dayville, Conn.	125	180	11,000	1	1923
Wisconsin Pr. & Lt. Co. Wild Rose, Wis.	125	180	9,000	1	1926
Walter Baker & Co. Milton, Mass.	93.8	150	10,000	3	1923
St. Charles, Ill., Hotel	62.5	164	13,000	2	1927

A 187-kva, 360-rpm waterwheel generator, Municipal Plant of City of Petoskey, Mich.

GENERAL ELECTRIC